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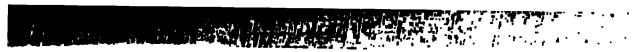


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# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY,

CONTAINING

PAPERS, ABSTRACTS OF PAPERS, AND

REPORTS OF THE PROCEEDINGS

OF THE SOCIETY

*FROM NOVEMBER* 1901 *TO NOVEMBER* 1902.

## VOL. LXII.

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# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. LXII. NOVEMBER 8, 1901. No. 1


Dr. J. W. L. GLAISHER, M.A., F.R.S., PRESIDENT, in the Chair.

Professor W. W. Campbell, Director of the Lick Observatory, San José, California, U.S.A. ;
Professor J. Scheiner, Astrophysical Observatory, Potsdam, Germany ; and
M. Ch. Trépied, Director of the Observatory, Algiers,

were balloted for and duly elected Associates of the Society.

Spencer Lavington Fletcher, 38 Lammas Park Road, Ealing, W. ; and
Professor Monroe B. Snyder, Director of the Observatory, Philadelphia, Pa., U.S.A.,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Ashton Charles Allen, 34 Kensington Palace Mansions, De Vere Gardens, W. (proposed by Rev. C. D. P. Davies) ;
John Hind Bell, *Nautical Almanac* Office, 3 Verulam Buildings, Gray's Inn, W.C. (proposed by A. M. W. Downing) ;
Walter Ernest Besley (H.M. Civil Service), 75 The Chase, Clapham Common, S.W. (proposed by F. W. Levander) ;

James Henry Booth, F.R.G.S., Schoolmaster, 32 Sunny Road, Southport (proposed by William Banks);

Arthur Thomas Cooper, A.M.Inst.E.E., Rivernook, De Montford Island, Reading (proposed by C. Hutchinson);

Joseph Alfred Hardcastle, 38 Eaton Square, S.W. (proposed by H. H. Turner);

Charles Sumner Howe, Ph.D., Professor of Astronomy, Case Observatory, Cleveland, Ohio, U.S.A. (proposed by Ambrose Swasey);

William Gylby Hutchinson, Rock Lodge, Roker, Sunderland (proposed by C. Hutchinson);

G. F. Johns, Perth Observatory, Western Australia (proposed by W. E. Cooke);

James William Lowber, M.A., Sc.D., Ph.D., LL.D., F.R.G.S., F.R.Met. Soc., 113 East 18th Street, Austin, Texas, U.S.A. (proposed by Captain M. C. Hepworth);

H. Krauss Nield, Thorold Grove, Sale, Cheshire (proposed by Samuel Chatwood);

Captain Michael Joseph O'Sullivan, Board of Trade Surveyor, 66 Fern Grove, Hartington Road, Sefton Park, Liverpool (proposed by H. G. Quirk);

Charles Tallent Spencer, A.M.Inst.C.E., La Quinta, Lyon Road, Harrow (proposed by A. G. Fowler); and

Rev. Charles Lakeman Tweedale, M.A., The Vicarage, Weston, near Ottley (proposed by R. Wilding).

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One hundred and ninety-one presents were announced as having been received since the last meeting, including amongst others :—

Tycho Brahe, De Nova Stella (facsimile edition), presented by the R. Academy of Sciences, Copenhagen; Harvard Annals, vol. 28, part 2 (spectra of bright southern stars), presented by the Observatory; Lick Observatory Publications, vol. 5 (Hussey's measures of double stars), presented by the Observatory; Observations of the total eclipse of 1898 January 22, presented by Sir N. Lockyer; Atlas photographique de la lune, par MM. Loewy et Puiseux, presented by the Paris Observatory; Carte photographique du Ciel (22 charts), presented by the Paris Observatory; Annals of the Astrophysical Observatory of the Smithsonian Institution, vol. 1, presented by the Institution; Photographs of the great Comet of 1901, presented by the Perth Observatory, Western Australia.

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*Note respecting the Printing of Tabular Matter in the Society's Publications.*

The Secretaries wish to draw the attention of Fellows who submit papers for publication in the *Memoirs* or *Monthly Notices* to the importance of drawing up tabular matter so as to fit the size of page as nearly as possible. Care in this respect will avoid the necessity which has sometimes arisen of printing tables the wrong way of the page. For example, a convenient form in which observations of double stars may be printed in the *Memoirs* will be found in *Mem.* vol. liii. pp. 294–307, and similarly for the *Monthly Notices* in *M.N.* vol. lxi. pp. 486–500. The form in the *Monthly Notices* may be taken as showing the maximum number of columns which can be printed on a page. As a rule, notes are best printed at the bottom of the page or at the end of a paper.

[SECRETARIES.]

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*Determination of Dr. Küstner's Magnitude Equation from Comparison of his Meridian Observations in Zones +24° to +27° with Measures of Photographic Plates taken at the University Observatory, Oxford.* By H. H. Turner, D.Sc., F.R.S., Savilian Professor.

1. Dr. F. Küstner, Director of the Bonn Observatory, has embarked on a fine piece of work which he describes in the following terms: the formation of a catalogue of a number of stars of all magnitudes from the 4th to the 10th, uniformly distributed over the sky, reduced to the system of the Fundamental Catalogue of the *Astronomische Gesellschaft*, special attention being given to the determination and elimination of the magnitude equation in both R.A. and declination, and both of the fundamental catalogue and of the observer himself. Two parts of this work have already appeared.* The first gives a catalogue of 4,070 stars in zones 0° to +18°, and the second a catalogue of 4,292 stars in zones +18° to +36°. The zones under survey at the University Observatory, Oxford, as part of the astrographic chart work extend from +24° to +32° (plate centres +25° to +31°), and the zones with centres +25° +26° +27° are complete, while those with centres +28° and +29° will probably be completed by the end of this year (thirty plates are yet unfinished). There is thus considerable material for

* *Veröffentlichungen der königl. Sternwarte zu Bonn*, Nos. 4 and 5.

comparison with Dr. Küstner's observations already, though a complete comparison cannot be made for a year or two. Since Dr. Küstner is directing special attention to the magnitude equation, which he investigates by the method of screens (cutting down the light of the bright stars for some transits and leaving it unobscured in others), it is of interest to give at once the totally independent determination afforded by photographic measures, which can be made with very little trouble.

2. In former papers (*Monthly Notices*, vol. lvii. p. 473, and vol. lx. p. 3) the magnitude equation of the Cambridge meridian observations was determined by comparison with Oxford photographic measures. The variation per magnitude was $0^s{\cdot}023$ for stars brighter than magnitude 8·0, but much more rapid (about $0^s{\cdot}100$) for fainter stars. In a note to the second paper (vol. lx. p. 11) it was stated that if the photographic method of determining magnitude equation were accepted as correct, the screen method seemed liable to underestimate the amount of the equation owing to difficulty in assigning the photometric value of the screen. It would have been interesting if the present comparison could have thrown further light on this point; but, unfortunately for this particular purpose, Dr. Küstner's magnitude equation is very small—practically zero. He obtains coefficients in R.A. of opposite signs in the two volumes published: for stars in zones 0° to +18° the result is $+0^s{\cdot}0070$; for zones +18° to +36° the result is $-0^s{\cdot}0041$; and it may be added that before beginning this work he got from the Victoria comparison stars the value $-0^s{\cdot}0040$. The result obtained from the subjoined comparison is $+0^s{\cdot}009$.

3. The comparison was effected as follows. In the course of the ordinary work at Oxford those stars which have been observed on the meridian at Cambridge, as part of the great catalogue of the *Astronomische Gesellschaft*, are used to get the plate constants. These being obtained, the residuals for the individual stars, in the sense Oxford − Cambridge, are entered in ledgers; and the mean of these residuals (for two or more separate plates as the case may be) is for the present purpose taken as the correction to the Cambridge place. The Cambridge places are given in the original catalogue for epoch 1875·0, but for use in our work they have been brought up to 1900·0, so that a comparison with Küstner (1900·0) is easily made. Adding then Oxford − Cambridge to Cambridge − Küstner we get Oxford − Küstner. The Cambridge places are thus nearly, but not quite, eliminated. Their influence remains in the means for all stars on a plate; if there were, for instance, a systematic error depending on R.A. running through the Cambridge Catalogue, this would remain in the Oxford photographic places. But since stars of all magnitudes would be equally affected this would not matter for our present purpose. The differences Oxford − Küstner for zones +24° to +27°, formed in this way, were grouped according to magnitude (as given by Küstner) and means taken as below. It

should be particularly remarked that *no observations made with screens were included in the comparison*, which is thus altogether independent of screens.

*Comparison of Oxford (Photographic) – Küstner (Visual) Zones + 24° to + 27° only.*

| Limits of Mag. | Adopted Mean Mag. | No. of Stars. | Oxford – Küstner. R.A. s | Dec. " | O – K Corrected. R.A. s | Dec. " |
|---|---|---|---|---|---|---|
| 7·1 to 8·0 | 7·5 | 49 | +0·138 | −0·08 | +0·014 | +0·11 |
| 8·1 to 8·5 | 8·3 | 52 | + ·116 | −0·24 | −0·015 | −0·13 |
| 8·6 & 8·7 | 8·65 | 35 | + ·132 | −0·22 | −0·003 | −0·15 |
| 8·8 & 8·9 | 8·85 | 44 | + ·132 | −0·05 | −0·004 | 0·00 |
| 9·0 & 9·1 | 9·05 | 68 | + ·132 | +0·02 | −0·006 | +0·04 |
| 9·2 | 9·2 | 44 | + ·136 | 0·00 | −0·004 | +0·01 |
| 9·3 | 9·3 | 37 | + ·148 | +0·08 | +0·007 | +0·07 |
| Over 9·3 | 9·6 | 38 | + ·156 | +0·04 | +0·013 | 0·00 |
| Means ... | 8·8 | 46 | + ·136 | −0·05 | | |

4. It is clear that the magnitude equation is very small, especially in R.A. If we assume a formula

$$a + b\,(\text{mag.} - 8{\cdot}8)$$

to represent the differences, and find $a$ and $b$ by "least squares," regarding the means for the groups as of equal weight, we get numerical values for $b$ as follows :—

in R.A. $+0^{s}{\cdot}009$ in Dec. $+0''{\cdot}11$

Küstner's values are, from zones $+18°$ to $+36°$ (in which the zones $+24°$ to $+27°$, which form the basis of the above comparison, are included)

in R.A. $-0^{s}{\cdot}0041$ in Dec. $+0''{\cdot}064$

while from zones $0°$ to $+18°$ he got the results

in R.A. $+0^{s}{\cdot}0070$ in Dec. $+0''{\cdot}105$

In the columns of the above table headed "O – K corrected" the residuals of the previous columns are given after subtracting $+0^{s}{\cdot}136 + (m - 8{\cdot}8)\,0^{s}{\cdot}009$ in R.A. and $-0''{\cdot}05 + (m - 8{\cdot}8)0''{\cdot}11$ in Decl.

5. As indicating the general accuracy of both sets of results (Küstner and Oxford), the following table showing the number of differences of various values may be interesting.

| | | | | |
|---|---|---|---|---|
| +0·03 | 3 | +0·20 | 11 | |
| +0·04 | 8 | +0·21 | 8 | |
| +0·05 | 6 | +0·22 | 7 | |
| +0·06 | 7 | +0·23 | 5 | |
| +0·07 | 15 | +0·24 | 3 | |
| +0·08 | 19 | +0·25 | 6 | |
| +0·09 | 16 | +0·26 | 0 | |
| +0·10 | 25 | +0·27 | 1 | - |
| +0·11 | 17 | +0·28 | 1 | - |
| +0·12 | 24 | +0·29 | 0 | - |
| +0·13 | 34 | +0·30 | 2 | |
| +0·14 | 28 | +0·31 | 1 | |
| +0·15 | 28 | +0·34 | 1 | |

*General Conclusi*

Dr. Küstner's magnitude equation s
parison with Oxford photographic me
agreement both in R.A. and Decl. w
using the method of screens ; but the q
settle the question whether the scree
values which should be multiplied by a
former paper.

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*On Periodic Orbits in the Neighbourhoo*
By H. C. Plummer.

has been called by Professor Darwin an *oscillating satellite*. Such orbits have been investigated recently by Dr. Charlier in a very interesting and suggestive paper.* The method which he has adopted is extremely simple and familiar, and several of his results had been given previously by Professor G. H. Darwin, in whose work the subject only presented itself incidentally, and by Mr. Moulton in his paper on the origin of the *Gegenschein*.† I wish here to discuss some of Dr. Charlier's results in a slightly more general manner. It is true that the direction in which greater generality can be secured without increased difficulty will lead us away from the problem of three bodies. But it is possible that the conclusions which follow will prove interesting in themselves, that they may conceivably find an application to some physical problem of a totally different order, and that something more may be learnt with regard to their general character and limitations. At any rate any attempt to draw wider attention to a subject which presents such a promising field for investigation may perhaps be justified.

2. Let us consider the motion of a particle in a rotating field of force. The forces are to be derived from a complete potential function $\Omega$, the precise form of which need not at present be defined except as some uniform function of $x$ and $y$, the coordinates referred to rotating axes. Then the equations of motion of the particle may by a suitable choice of units be expressed in the form

$$\ddot{x}-2\dot{y}=\frac{\partial\Omega}{\partial x}$$

$$\ddot{y}+2\dot{x}=\frac{\partial\Omega}{\partial y}$$

As is well known these apply in particular to the motion of a body of infinitesimal mass under the influence of two bodies revolving in circles about their centre of gravity. Now let a centre of libration be defined as a point whose coordinates $(x, y)$ satisfy the relations

$$\frac{\partial\Omega}{\partial x}=\frac{\partial\Omega}{\partial y}=0$$

At such a point equilibrium, which may be either stable or unstable, is possible. Now let a surface be defined by the equation $z=\Omega$, and let the ordinary notation be adopted, viz.

$$\frac{\partial z}{\partial x}=p \qquad \frac{\partial z}{\partial y}=q$$

$$\frac{\partial^2 z}{\partial x^2}=r \qquad \frac{\partial^2 z}{\partial x\partial y}=s \qquad \frac{\partial^2 z}{\partial y^2}=t$$

* *Meddelanden från Lunds Astronomiska Observatorium*, No. 18.
† *Astr. Journ.*, No. 483.

$$\ddot{\xi} - 2\dot{\eta} = r\xi + s\eta$$
$$\ddot{\eta} + 2\dot{\xi} = s\xi + t\eta$$

Then $\xi = Ae^{\lambda t}$, $\eta = Be^{\lambda t}$ satisfy the equatio

$$A(\lambda^2 - r) - B(2\lambda + s)$$
$$A(2\lambda - s) + B(\lambda^2 - t) =$$

*i.e.* $$(\lambda^2 - r)(\lambda^2 - t) + 4\lambda^2 - s^2 =$$

or $$\lambda^4 + \lambda^2(4 - r - t) + rt - s^2 =$$

Stability depends on the nature of the root

3. Now let $\rho_1$, $\rho_2$ be the principal rad corresponding point of the surface $z = \Omega$. are the roots of the quadratic

$$(rt - s^2)\rho^2 + (r + t)\rho + 1 =$$

Hence we may rewrite the preceding equati

$$\lambda^4 + \lambda^2\left(4 + \frac{1}{\rho_1} + \frac{1}{\rho_2}\right) + \frac{1}{\rho_1\rho_2} =$$

By means of this equation the conditions at a centre of libration are immediately con perties of the surface $z = \Omega$. For perfect st that both values of $\lambda^2$ shall be real and n must in the first place have both $\rho_1$ and $\rho_2$ surface synclastic at the point, and $z$ a real minimum. The second condition is that

$$4 + \frac{1}{\rho_1} + \frac{1}{\rho_2} > 2$$

Thus, while in a stationary field of force equilibrium is stable where the force function is a maximum only, in a rotating field the function $\Omega$, which it must be remembered includes the rotation potential, may be either a maximum or a minimum, provided in the latter case a certain inequality is satisfied. On the other hand we may have one value of $\lambda^2$ negative and the other positive. This corresponds to curvatures of opposite sign or an anticlastic point on the $\Omega$ surface. In this case a mode of periodic motion is combined with an unstable mode which must sooner or later prove fatal to the stable form. Neither purely positive nor imaginary values of $\lambda^2$ can be admitted in a search for periodic orbits.

4. I consider first the far more interesting case in which two periodic solutions are possible. Let us assume

$$\xi = h\cos(mt-\alpha) \qquad \eta = k\cos(mt-\beta)$$

as a periodic solution of the equations

$$\ddot{\xi} - 2\dot{\eta} = r\xi - s\eta$$
$$\ddot{\eta} + 2\dot{\xi} = s\xi + t\eta$$

The conditions obtained by substitution are

$$(r+m^2)\,h\cos\alpha + sk\cos\beta = -2mk\sin\beta$$
$$(r+m^2)\,h\sin\alpha + sk\sin\beta = \quad 2mk\cos\beta$$
$$(t+m^2)\,k\cos\beta + sh\cos\alpha = \quad 2mh\sin\alpha$$
$$(t+m^2)\,k\sin\beta + sh\sin\alpha = -2mh\cos\alpha$$

Hence we obtain directly

$$(r+m^2)\,h\sin(\alpha-\beta) = 2mk$$
$$sk\sin(\alpha-\beta) = -2mk\cos(\alpha-\beta)$$
$$(t+m^2)\,k\sin(\alpha-\beta) = \quad 2mh$$
$$sh\sin(\alpha-\beta) = -2mh\cos(\alpha-\beta)$$

which are equivalent to

$$h^2(r+m^2) = k^2(t+m^2)$$
$$s\tan(\alpha-\beta) = -2m$$
$$4m^2\operatorname{cosec}^2(\alpha-\beta) = (r+m^2)(t+m^2) = 4m^2+s^2$$

Hence the periodic orbit is obtained by combining two simple harmonic motions at right angles. These motions are characterised by a constant ratio of the amplitudes and a constant difference of phase for each centre of libration and assigned period. The orbits may be illustrated by Lissajou's figures for tuning-forks in unison. This is a very simple way of stating the

...s, according as equi
maximum or minimum value of Ω. T
sidered first. Then both $r$ and $t$ are p

$$c^2=h^2(r+m^2)=k^2(t$$

and since

$$s(r+m^2)hk\sin^2(\alpha-\beta)=-4\eta$$

we have also

$$-hk\,.\,s\sec(\alpha-\beta)=$$

The orbit becomes

$$(r+m^2)\xi^2+(t+m^2)\eta^2+2s\xi\eta=4\eta$$

and the axes and foci are given by

$$\frac{\xi^2-\eta^2}{r-t}=\frac{\xi\eta}{s}=-\frac{c^2}{4m^2+}$$

The directions of the axes depend, the potential alone, and the major axis lies quadrants if $s$ is negative, in the seco positive. But for the surface $z=\Omega$

$$z+\delta z=\Omega+p\xi+q\eta+\tfrac{1}{2}(r\xi^2+2s$$

or

$$2\delta z=r\xi^2+2s\xi\eta+t\eta^2$$

is the indicatrix corresponding to a cer axes and foci are given by

**6.** The semi-axes $a$, $b$ of the orbit are given by

$$\frac{1}{a^2}+\frac{1}{b^2}=(r+t+2m^2)\,(4m^2+s^2)\,/4m^2c^2$$

$$\frac{1}{a^2b^2}=(4m^2+s^2)^2/4m^2c^4$$

Hence $a^2$ and $b^2$ are the roots of the quadratic

$$(4m^2+s^2)^2\,x^2-(r+t+2m^2)\,(4m^2+s^2)c^2x+4m^2c^4=0$$

$$\therefore\ 2(4m^2+s^2)\,.\,x/c^2=r+t+2m^2 \pm\sqrt{\{4m^4+4m^2(r+t-4)+(r+t)^2\}}$$

$$=r+t+2m^2\pm\sqrt{\{4(s^2-rt)+(r+t)^2\}}$$

$$=2m^2-\left(\frac{1}{\rho_1}+\frac{1}{\rho_2}\right)\pm\left(\frac{1}{\rho_1}-\frac{1}{\rho_2}\right)$$

We may therefore write

$$a^2=c^2\left(m^2-\frac{1}{\rho_1}\right)/(4m^2+s^2)$$

$$b^2=c^2\left(m^2-\frac{1}{\rho_2}\right)/(4m^2+s^2)$$

where $\rho_1$ is the numerically smaller of the two radii of curvature, for these are both negative. Accordingly the eccentricity $e$ is given by

$$e^2=(\rho_2^{-1}-\rho_1^{-1})/(m^2-\rho_1^{-1})$$

and we notice that a circular orbit corresponds to an umbilic on the $\Omega$ surface.

**7.** We can now examine the initial conditions and the relation of our constant $c$ to the constant C of the Jacobian integral

$$V^2=2\Omega-C$$

Let $(\xi_0.\ \eta_0)$ be the position at the time $t=0$. Then since

$$\xi=h\cos(mt-\alpha)\quad \eta=k\cos(mt-\beta)$$

we have

$$\xi_0=h\cos\alpha \qquad \eta_0=k\cos\beta$$

$$\dot{\xi}_0=mh\sin\alpha \qquad \dot{\eta}_0=mk\sin\beta$$

$$\therefore\ V^2=\dot{\xi}_0^2+\dot{\eta}_0^2=m^2(h^2+k^2)-m^2(\xi_0^2+\eta_0^2)$$

But

$$2\Omega=2\Omega_0+r\xi_0^2+t\eta_0^2+2s\xi_0\eta_0$$

where $\Omega_0$ is the value of $\Omega$ corresponding to the centre of libration. If $2\,\Omega_0=C_0$

$$C=C_0-m^2(h^2+k^2)+(r+m^2)\xi_0^2+(t+m^2)\eta_0^2+2s\xi_0\eta_0$$

Thus for a given value of $C-C_o$, $\xi_o$ and $\eta_o$ must satisfy the equation of a certain ellipse which can be no other than the orbit already found. Hence by comparison we find

$$\begin{aligned} C-C_o &= 4m^2c^2/(4m^2+s^2)-m^2(h^2+k^2) \\ &= \frac{4m^2c^2}{4m^2+s^2}-\frac{m^2c^2(2m^2+r+t)}{(m^2+r)(m^2+t)} \\ &= m^2c^2(4-r-t-2m^2)/(4m^2+s^2) \end{aligned}$$

Now if $m_1^2$ and $m_2^2$ are the roots of the quadratic giving $m^2$

$$m_1^2+m_2^2=4-r-t$$

or

$$(2m_1^2+r+t-4)+(2m_2^2+r+t-4)=0$$

Hence $C-C_o$ clearly has opposite signs according to the period selected, that is, one period and one eccentricity correspond to an increase, and the other period and eccentricity to a decrease of the energy constant as compared with the value required for relative rest. Thus when stable equilibrium exists at a point where $\Omega$ is a minimum a given value of C determines the orbit uniquely. Dr. Charlier has noticed this in a particular case, but his proof is not of a general character. Another peculiarity is that one family of orbits is bounded by a set of "limiting curves," while the other is not.

8. The period of the orbit is $2\pi/m$. But the units have been so chosen that the period of rotation of the field of force is $2\pi$. Therefore $m$ may be defined as the ratio of the period of the rotating field to the synodic period of the orbit. The direction of motion is determined by the sign of

$$\begin{aligned} \xi\dot{\eta}-\dot{\xi}\eta &= -mhk\sin(\alpha-\beta) \\ &= -2m^2c^2/(4m^2+s^2) = -mab \end{aligned}$$

The angular momentum being negative, the orbits of both families are retrograde. If it is desired to write down the equation of an orbit in a form involving only the energy constant and quantities depending only on $\Omega$, we are led to

$$\begin{aligned} (r+m^2)\xi^2+(t+m^2)\eta^2+2s\xi\eta &= 4(C-C_o)/(4-r-t-2m^2) \\ &= 4n(C-C_o) \end{aligned}$$

where

$$\begin{aligned} n^{-2} &= (4-r-t)^2-4(rt-s^2) \\ &= \left(\frac{1}{\rho_1}-\frac{1}{\rho_2}\right)^2+8\left(\frac{1}{\rho_1}+\frac{1}{\rho_2}\right)+16 \end{aligned}$$

It may be observed that it is the family of shorter period and smaller eccentricity which requires $C < C_o$.

9. Throughout §§ 5–8 it has been assumed that $\Omega$ is an absolute minimum at the centre of libration, and that accordingly

$r$ and $t$ are positive. This indeed happens to be the more interesting case in so far as the problem of three bodies is concerned because there the function $\Omega$ does not as a matter of fact possess a truly maximum value. But if $\Omega$ is an absolute maximum both $r$ and $t$ are negative. It will be convenient to denote the quadratic giving $m^2$ by $f(m^2)=0$. By substitution we obtain :

$$\left.\begin{aligned} f(-r) &= 4r-s^2 \\ f(-t) &= 4t-s^2 \end{aligned}\right\} \text{ are negative.}$$

$$f(+\infty) \text{ is positive.}$$

$$f(0) = rt-s^2 \text{ is positive.}$$

Hence $-r$ and $-t$ separate the two positive roots $m_1^2$ and $m_2^2$. It is clear then that when $\Omega$ is a maximum $m_1^2+r$ and $m_1^2+t$ are negative, while $m_2^2+r$ and $m_2^2+t$ are positive if $m_2^2 > m_1^2$. Further, since

$$4-r-t-2m_1^2 > 0$$

we must have

$$4-r-t-2m_2^2 < 0$$

The orbits of shorter period, $2\pi/m_2$, are then similar to the orbits investigated in the case when $\Omega$ is a minimum, and they require that $C < C_0$. It is unnecessary to consider this family in further detail. It is only in the expressions for the semi-axes and eccentricity given in § 6 that it is necessary to interchange the two radii of curvature on account of the change of sign.

10. The family of orbits characterised by the longer period $2\pi/m_1$ possesses features, however, which require separate notice. In the place of $+c^2$ in the foregoing it is necessary to write $-c^2$. The formula given for the foci in § 5 shows that the major axis of a member of this family is at right angles to the corresponding axis of a short-period orbit. Further from § 8 it appears that the direction of motion is reversed and orbits of this family are direct. Since both $c^2$ and $(4-r-t-2m^2)$ have opposite signs in the two families we again have $C < C_0$. Consequently to any given value of C $C_0$ one orbit of each family corresponds. Indeed the Jacobian integral suffices to prove that $C > C_0$ ; for otherwise since $2\Omega_0 \sim 2\Omega$, the velocity of the displaced body would be imaginary. Hence the extension of Dr. Charlier's statement given in § 7 of this paper, must be restricted to cases where $\Omega$ is a minimum. The expressions given for the semi-axes in § 6 require no alteration, although the radii of curvature are positive : for $(m_1^2-\rho_1^{-1})$ and $(m_1^2-\rho_2^{-1})$ must be negative, and therefore $\rho_1^{-1} > \rho_2^{-1}$. The most interesting features of the family of orbits considered here are undoubtedly the change from retrograde to direct motion and the rotation of the major axis through a right angle.

11. When $\Omega$ is a maximum at the centre of libration, we have seen that two orbits correspond to one value of C. Again,

through a point two orbits can be drawn, and for these the values of C will in general be different. There are, however, points where two orbits of different families, and the same C meet. The orbits will be

$$(m_1^2+r)\xi^2+(m_1^2+t)\eta^2+2s\xi\eta=+4n(C-C_0)$$
$$(m_2^2+r)\xi^2+(m_2^2+t)\eta^2+2s\xi\eta=-4n(C-C_0)$$

Hence the locus of their intersection is

$$(m_1^2+m_2^2+2r)\xi^2+(m_1^2+m_2^2+2t)\eta^2+4s\xi\eta=0$$

Or since $$m_1^2+m_2^2=4-r-t$$

$$(4+r-t)\xi^2+(4-r+t)\eta^2+4s\xi\eta=0$$

This represents a pair of straight lines equally inclined to the axes of the orbit, and this is clear from the geometrical interpretation. For since C is the same for both orbits, the velocity in each at the point of intersection is the same. Hence the central perpendiculars on the tangents are equal, and it becomes evident that the above equation represents the locus of points where orbits of the two families intersect each other, and are equally inclined to the common radius vector. The locus will not be real unless

$$4s^2+(r-t)^2>16$$

*i.e.* $$\rho_1^{-1}\sim\rho_2^{-1}>4$$

And unless this condition is satisfied corresponding members of the two families will not intersect, so that one orbit will lie wholly within the other.

12. When at a centre of libration the function $\Omega$ is neither an absolute maximum nor an absolute minimum, oscillating satellites may still exist. In this case only one class of orbit is possible, and even this cannot be permanently stable. The equation $f(m^2)=0$ has one positive root and one negative. Since the equation

$$(2m_1^2+r+t-4)+(2m_2^2+r+t-4)=0$$

still holds, the first expression on the left hand must be positive if $m_1^2>0>m_2^2$. Hence $(2m_1^2+r+t)$ is positive, and since $(m_1^2+r)$ and $(m_1^2+t)$ must be of the same sign, if an elliptic orbit exists they must both be positive. Hence $C<C_0$, and the orbits possess the same general features as those of shorter period when $\Omega$ is a minimum. An unstable form of motion arises immediately if $C>C_0$, and this would be the case if motion in the periodic orbit be unduly retarded. We should infer that excess rather than defect of relative velocity would be favourable to the duration of quasi-stable motion, and this may have some bearing on the theory of the detention of meteorites in the neighbourhood of a centre of libration. We have seen that in general the direction

of the major axis of an orbit depends on the sign of $s$. An exception, of course, arises when $s=0$. This point happens to occur in the application of this paragraph, and may properly be considered in this connection. The formula given in § 5 for the foci of the orbit shows that the axes are parallel to the rotating axes of coordinates, and that the major axis is parallel or perpendicular to the line joining the controlling bodies, according as $r-t<$ or $>0$. The only exception to this rule is in the case of long-period orbits corresponding to $\Omega$ a maximum, when the preceding inequalities are reversed.

13. About the special problem which suggested the foregoing slightly more general investigation, little need be said here, because it has been treated with some fullness by Dr. Charlier. But as I have had occasion to allude to the properties of the surface defined by the equation $z=\Omega$, it may not be out of place to consider briefly the nature of the surface determined by two bodies revolving in circles about their centre of gravity. The sum of the masses $\mu$ and $\nu$ is taken as the unit of mass, while the unit of time is such that the gravitational constant is unity and the unit of length the distance between the masses. Then the period $T=2\pi$, the angular velocity is unity, and we have

$$2\Omega=\mu\left(r_1^2+\frac{2}{r_1}\right)+\nu\left(r_2^2+\frac{2}{r_2}\right)$$

where $r_1$, $r_2$ are the distances from $\mu$ and $\nu$ respectively. Now Professor Darwin in his memoir * has drawn a typical series of the curves $2\Omega=$const., and if these be regarded not merely as a family of curves with an arbitrary parameter, but as a set of contour lines of a surface, we easily get a fair notion of the general character of that surface. Much indeed can be gathered from the simplest reasoning. At the two points where $r_1=r_2=1$, it is easy to prove that $2\Omega$ is a true minimum and equal to 3. The familiar topographical illustration will be useful here. At each of these minimum points there is a valley. The function $\Omega$ becomes infinite at the points where the masses are placed, but for the present purpose these points may be represented by the summits of mountains. The contour lines, which are evidently symmetrical with respect to the line joining the masses, must rapidly approach a circular form as they recede from the centres of force and indicate rising ground in all directions outwards. The additional features of the surface must clearly be three passes, one running between the mountains and connecting the valleys, and two others beyond the two mountains and separating them from the ground rising in the distance. Each of the three passes has its highest point on the line of symmetry, and these three points correspond to the three collinear centres of libration. Here the $\Omega$ surface is anticlastic, and, as indeed is evident on dynamical grounds, stable equilibrium is out of the question.

* *Acta Math.*, t. xxi. p. 113.

14. Although there cannot be any doubt as to the nature of these points, yet it may be permissible to consider them from another point of view. In what follows the origin is taken at the centre of gravity of the revolving bodies, the latter always lying on the rotating axis of $x$. Since

$$2\Omega = \mu\left(r_1^2 + \frac{2}{r_1}\right) + \nu\left(r_2^2 + \frac{2}{r_2}\right)$$

we have

$$\frac{\partial\Omega}{\partial r_1} = \mu\left(r_1 - \frac{1}{r_1^2}\right); \quad \frac{\partial\Omega}{\partial r_2} = \nu\left(r_2 - \frac{1}{r_2^2}\right)$$

Also for the collinear centres of libration

$$y = 0; \quad \frac{\partial\Omega}{\partial x} = 0$$

or

$$\frac{\partial\Omega}{\partial r_1}\cdot\frac{\partial r_1}{\partial x} + \frac{\partial\Omega}{\partial r_2}\cdot\frac{\partial r_2}{\partial x} = 0$$

Moreover

$$\frac{\partial\Omega}{\partial y} = \frac{\partial\Omega}{\partial r_1}\cdot\frac{\partial r_1}{\partial y} + \frac{\partial\Omega}{\partial r_2}\cdot\frac{\partial r_2}{\partial y}$$

$$= \frac{y}{r_1}\cdot\frac{\partial\Omega}{\partial r_1} + \frac{y}{r_2}\cdot\frac{\partial\Omega}{\partial r_2}$$

Hence when $y = 0$

$$t = \frac{\partial^2\Omega}{\partial y^2} = \frac{1}{r_1}\cdot\frac{\partial\Omega}{\partial r_1} + \frac{1}{r_2}\cdot\frac{\partial\Omega}{\partial r_2}$$

$$s = \frac{\partial^2\Omega}{\partial x\partial y} = 0$$

We have now to treat separately the cases which arise.

(1) Between the masses $\mu$ and $\nu$ we have

$$r_1 + r_2 = 1; \quad \frac{\partial r_1}{\partial x} + \frac{\partial r_2}{\partial x} = 0$$

$$\therefore \frac{\partial\Omega}{\partial r_1} = \frac{\partial\Omega}{\partial r_2}$$

$$\therefore \mu\left(\frac{1}{r_1^2} - r_1\right) = \nu\left(\frac{1}{r_2^2} - r_2\right)$$

Hence clearly $r_1 > r_2$ if $\mu > \nu$. In this case

$$t = \left(\frac{1}{r_1} + \frac{1}{r_2}\right)\cdot\mu\left(r_1 - \frac{1}{r_1^2}\right)$$

and is negative, for $r_1 < 1$.

(2) Beyond the mass $\mu$ we have

$$r_2 = r_1 + 1 \; ; \; \frac{\partial r_1}{\partial x} = \frac{\partial r_2}{\partial x}$$

$$\therefore \frac{\partial \Omega}{\partial r_1} + \frac{\partial \Omega}{\partial r_2} = 0$$

$$\therefore \mu\left(\frac{1}{r_1^2} - r_1\right) = \nu\left(r_2 - \frac{1}{r_2^2}\right)$$

Hence clearly $r_1 < 1$. In this case

$$t = \left(\frac{1}{r_1} - \frac{1}{r_2}\right) \cdot \mu\left(r_1 - \frac{1}{r_1^2}\right)$$

and is negative because $r_1 < 1 < r_2$, and therefore the first factor is positive and the last negative. The proof that $t$ is negative in the case of the centre of libration lying beyond the mass $\nu$ can be inferred from the latter, as there is no restriction on the ratio of the masses $\mu$ and $\nu$. Now we have

$$r = \frac{\partial^2 \Omega}{\partial x^2} = \mu\left(1 + \frac{2}{r_1^3}\right) + \nu\left(1 + \frac{2}{r_2^3}\right)$$

which is necessarily positive. Hence always for the three points considered

$$rt - s^2 < 0$$

and therefore the two roots of the quadratic in $m^2$ are of opposite signs. I have thought it worth while to give a definite proof of this fact because on this point Dr. Charlier says: "That is what I have found through numerical calculation for different values of $\mu$, an algebraic demonstration of this fact seeming to be somewhat complicated."

*University Observatory, Oxford:*
1901 *October* 1.

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*A New Method of Interpolation.* By T. C. Hudson, B.A.

1. Bessel's interpolation formula is

$$u_n - u_0 = n\Delta'_{\frac{1}{2}} + \frac{n(n-1)}{1 \cdot 2}\frac{\Delta_0'' + \Delta_1''}{2} + \frac{n(n-1)(n-\frac{1}{2})}{1 \cdot 2 \cdot 3}\Delta_{\frac{1}{2}}''' + \frac{(n+1)n(n-1)(n-2)}{1 \cdot 2 \cdot 3 \cdot 4}\frac{\Delta_0^{\text{iv}} + \Delta_1^{\text{iv}}}{2} + \ldots \quad (1)$$

2. As it stands this formula is partially symmetrical with respect to the middle of the interval; but there is no symmetry

in the first three terms, namely, $u_n$, $u_0$ and $n\Delta'_{\frac{1}{2}}$, and the symmetry of the last three does not present itself obviously to the eye. If, however, we replace

$$\frac{u_0+u_1}{2}, \frac{1}{1\cdot 2}\cdot\frac{\Delta_0''+\Delta_1''}{2}, \frac{1}{1\cdot 2\cdot 3\cdot 4}\cdot\frac{\Delta_0^{\mathrm{IV}}+\Delta_1^{\mathrm{IV}}}{2}, \Delta'_{\frac{1}{2}}, \Delta'''_{\frac{1}{2}}, \tfrac{1}{2}-n, u_n$$

by $\mathrm{M}$, $\mathrm{M}''$, $\mathrm{M}^{\mathrm{IV}}$, $\Delta'$, $\Delta'''$, $m$, $\mathrm{U}_{+m}$

equation (1) becomes

$$\mathrm{U}_{+m} = \mathrm{M} - (\tfrac{1}{4}-m^2)\mathrm{M}'' + (\tfrac{1}{4}-m^2)(\tfrac{9}{4}-m^2)\mathrm{M}^{\mathrm{IV}} - \ldots$$
$$- m\Delta' + m(\tfrac{1}{4}-m^2)\frac{\Delta'''}{6} - \ldots$$

(a modification of Bessel's formula due, it appears, to Newton) which may be written

$$\mathrm{U}_{+m} = [\mathrm{E}]+[\mathrm{O}]$$

where $$[\mathrm{E}] = \mathrm{M} - (\tfrac{1}{4}-m^2)\mathrm{M}'' + (\tfrac{1}{4}-m^2)(\tfrac{9}{4}-m^2)\mathrm{M}^{\mathrm{IV}} - \ldots$$

containing only *even* differences and *even* powers of $m$,

and $$[\mathrm{O}] = -m\Delta' + m(\tfrac{1}{4}-m^2)\frac{\Delta'''}{6} - \ldots$$

containing only *odd* differences and *odd* powers of $m$.

In the E equation it will be seen that M takes its place naturally with $\mathrm{M}''$, $\mathrm{M}^{\mathrm{IV}}$, &c., its coefficient obeying the same law as theirs, and that the original quantities may be justly regarded as belonging to the family of even differences.

3. Changing the sign of $m$, and observing that $\mathrm{U}_{-m}$ is merely $u_{1-n}$, we have

$$\mathrm{U}_{-m} = [\mathrm{E}]-[\mathrm{O}].$$

By these substitutions we have now arrived at a pair of formulæ

$$\left\{\begin{array}{l}\mathrm{U}_{+m} = [\mathrm{E}]+[\mathrm{O}] \\ \mathrm{U}_{-m} = [\mathrm{E}]-[\mathrm{O}]\end{array}\right\} \quad \ldots\ldots\ldots \quad (2)$$

which possesses the practical, economic advantage of being symmetrical with respect to the middle of the interval.

4. The advantage consists in this, that when once [E] and [O] have been computed for the first half of the interval, and their sum has given the *first* half of the new quantities ($u_n$ or $\mathrm{U}_{+m}$), then their difference gives the *second* half without further computation. This means a saving of half the labour involved in a great part of the work of systematic interpolation. Moreover, the more new quantities we have to interpolate between the old data, the greater (relatively) becomes this economy. In particular, to take the opposite extreme, in the simplest case, that of "bisection," where we should want only midway quantities, we

observe that $m$, [O], and the difference between the formulæ (2) would all vanish together—likewise the economy.

But in the actual case of the work of deriving the Moon's hourly places for the *Nautical Almanac* from twelve-hourly data throughout a whole year, the degree of subdivision of the original interval into twelve new ones is so great that the aforesaid economy becomes an important consideration.

5. For this reason I found it worth while, a few years ago, to make new tables for the interpolation of the Moon's hourly R.A. and Dec., in which case (known variously as "interpolation to twelfths" and as "interval twelve") we have the following values :—

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| of $12n$ | viz. | 1 | 2 | 3 | 4 | 5→ | 6 |
| | | 11 | 10 | 9 | 8 | 7← | |
| of $12m$ | ,, | ± 5 | ± 4 | ± 3 | ± 2 | ± 1⇄ | 0 |
| of the coefficients of | | | | | | | |
| $\frac{\Delta'}{12}$ in [O] | ,, | ∓ 5 | ∓ 4 | ∓ 3 | ∓ 2 | ∓ 1⇄ | 0 |
| $\frac{1}{6}\frac{\Delta'''}{12^3}$ in [O] | ,, | ±55 | ±80 | ±81 | ±64 | ±35⇄ | 0 |
| $\frac{1}{144}\left(M''-\frac{317}{144}M^{iv}\right)$ in [E] | ,, | −11 | −20 | −27 | −32 | −35⇄ | −36 |
| and of the residual coefficients of | | | | | | | |
| $\frac{1}{2}\frac{M^{iv}}{12^3}$ in [E] | viz. | −33 | −30 | − 9 | +16 | +35⇄ | +42 |

6. With regard to these tabulated coefficients it may be noted

(*a*) That no other interpolation formula gives such simple coefficients as it stands, nor could it be made to do so by any other modification without seriously impairing the simplicity of treatment of the original differences, and also introducing additional sources of cumulative error.

(*b*) That the second coefficient of $\frac{M''}{144}$ is $-20$, *i.e.* the second coefficient of $\frac{\text{mean } \Delta''}{144}$ is $-10$. This is a most happy coincidence, and it means that the second member of the series of $\Delta''$ corrections happens to be numerically identical with ten times the new middle $\delta''$, so that we are practically getting two things at once, and we have an opportunity of condensing the corresponding table by making the second column do double duty by acting as vertical argument as well. There are other practical advantages of this coincidence which will appear later. Suffice it here to say

that it is the $\Delta''$ table that has hitherto caused the most trouble in construction and in use, and that it is this very table which is hereby simplified.

(*c*) That with a view to (i) dispensing as often as possible with $\Delta^{iv}$ corrections (as such) without seriously impairing the simplicity of treatment of the original second differences, and (ii) at the same time minimising resulting error (whether individual or mean, neglected or corrected), I have selected the particular device (as in the above table of coefficients) of subtracting $\frac{3}{1725}$ of the mean $\Delta^{iv}$ from the mean $\Delta''$, on the grounds that the resulting "residual $\Delta^{iv}$ corrections" are generally negligible, that their mean algebraical value throughout an interval is *zero*, and their maximum value is about half a thousandth of the original mean $\Delta^{iv}$, so that these residuals may be tabulated in three or four lines only, and then never referred to except as a matter of fact when the Moon is near a maximum declination, and that declination is also a large one by reason of the position of the Moon's node. Other devices might have been chosen, but at the sacrifice of one or more of these practical advantages. Moreover, further pursuit of this same method (such as entrusting the broad fifth-difference effect to the third-differences) would on the whole in each case rather complicate than expedite the work.

7. In the tables, which are purely *additive*, only such information is given as is necessary and sufficient, (*a*) to produce the end figure of the new quantities, and (*b*) to enable the calculator to fill in the rest with ease. By this economy the tables are reduced to very small compass.

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*Comparisons of the Geocentric Places of Uranus, Neptune, and the Sun, calculated from Newcomb's Tables, with their Places calculated from Le Verrier's Tables, for the Year* 1904. By A. M. W. Downing, D.Sc., F.R.S.

This paper is a continuation of one printed in *Monthly Notices*, vol. lix., No. 10. The *Nautical Almanac* for 1904 is the first in which Newcomb's Tables of *Uranus* and *Neptune* are used, and a comparison is made at convenient intervals throughout the year between the places there given for Greenwich noon and the corresponding places computed from those given in the *Connaissance des Temps* for 1904 for Paris noon.

I have also added a comparison of the Sun's places, deduced in the same manner, at intervals of eight days throughout the year.

URANUS, 1904.—*Corrections to Le Verrier's Tables.*

| Day. 1904. | R.A. Time. | R.A. Arc. | Dec. | Day. 1904. | R.A. Time. | R.A. Arc. | Dec. |
|---|---|---|---|---|---|---|---|
| | s | " | " | | s | " | " |
| Jan. 1 | −·33 | −4·5 | +0·1 | July 3 | −·34 | −4·7 | 0·0 |
| Feb. 2 | −·34 | −4·7 | 0·0 | Aug. 4 | −·33 | −4·5 | +0·2 |
| Mar. 1 | −·36 | −4·9 | 0·0 | Sept. 1 | −·34 | −4·7 | +0·1 |
| Apr. 2 | −·36 | −4·9 | 0·0 | Oct. 3 | −·31 | −4·2 | +0·1 |
| May 4 | −·37 | −5·1 | +0·1 | Nov. 4 | −·31 | −4·2 | −0·1 |
| June 1 | −·36 | −4·9 | −0·1 | Dec. 2 | −·32 | −4·4 | −0·2 |

NEPTUNE, 1904.—*Corrections to Le Verrier's Tables.*

| Day. 1904. | R.A. Time. | R.A. Arc. | Dec. | Day. 1904. | R.A. Time. | R.A. Arc. | Dec. |
|---|---|---|---|---|---|---|---|
| | s | " | " | | s | " | " |
| Jan. 1 | −·38 | −5·3 | −2·0 | July 3 | −·38 | −5·3 | −1·8 |
| Feb. 2 | −·41 | −5·7 | −1·8 | Aug. 4 | −·38 | −5·3 | −1·7 |
| Mar. 1 | −·41 | −5·7 | −1·9 | Sept. 1 | −·40 | −5·6 | −1·7 |
| Apr. 2 | −·39 | −5·4 | −1·9 | Oct. 3 | −·41 | −5·7 | −1·8 |
| May 4 | −·39 | −5·4 | −1·8 | Nov. 4 | −·41 | −5·7 | −1·9 |
| June 1 | −·38 | −5·3 | −1·7 | Dec. 2 | −·41 | −5·7 | −1·9 |

SUN, 1904.—*Corrections to Le Verrier's Tables.*

| Day. 1904. | R.A. Time. | R.A. Arc. | Dec. | Day. 1904. | R.A. Time. | R.A. Arc. | Dec. |
|---|---|---|---|---|---|---|---|
| | s | " | " | | s | " | " |
| Jan. 1 | −·06 | −0·8 | −0·2 | May 24 | −·02 | −0·3 | +0·1 |
| 9 | −·04 | −0·6 | −0·3 | June 1 | −·01 | −0·1 | +0·3 |
| 17 | −·04 | −0·6 | −0·2 | 9 | −·01 | −0·1 | +0·2 |
| 25 | −·04 | −0·6 | −0·3 | 17 | −·02 | −0·3 | +0·3 |
| Feb. 2 | −·03 | −0·4 | −0·2 | 25 | −·02 | −0·3 | +0·2 |
| 10 | −·03 | −0·4 | −0·3 | July 3 | −·02 | −0·3 | +0·2 |
| 18 | −·03 | −0·4 | −0·4 | 11 | −·03 | −0·4 | +0·3 |
| 26 | −·03 | −0·4 | −0·3 | 19 | −·02 | −0·3 | +0·3 |
| Mar. 5 | −·03 | −0·4 | −0·1 | 27 | −·02 | −0·3 | +0·3 |
| 13 | −·02 | −0·3 | −0·1 | Aug. 4 | −·02 | −0·3 | +0·2 |
| 21 | −·03 | −0·5 | −0·2 | 12 | −·02 | −0·3 | +0·2 |
| 29 | −·03 | −0·5 | −0·1 | 20 | −·03 | −0·4 | +0·3 |
| Apr. 6 | −·01 | −0·1 | 0·0 | 28 | −·02 | −0·3 | +0·2 |
| 14 | −·02 | −0·3 | −0·1 | Sept. 5 | −·03 | −0·4 | +0·2 |
| 22 | −·02 | −0·3 | 0·0 | 13 | −·04 | −0·6 | +0·3 |
| 30 | −·01 | −0·1 | +0·1 | 21 | −·04 | −0·6 | +0·3 |
| May 8 | −·02 | −0·3 | +0·2 | 29 | −·04 | −0·6 | +0·1 |
| 16 | −·01 | −0·1 | +0·2 | Oct. 7 | −·05 | −0·7 | +0·2 |

| Day. 1904. | R.A. Time. | R.A. Arc. | Dec. | Day. 1904. | R.A. Time. | R.A. Arc. | Dec. |
|---|---|---|---|---|---|---|---|
| | s | " | " | | s | " | " |
| Oct. 15 | −·05 | −0·7 | +0·3 | Nov. 24 | −·06 | −0·8 | −0·1 |
| 23 | −·06 | −0·9 | +0·1 | Dec. 2 | −·05 | −0·7 | −0·1 |
| 31 | −·06 | −0·9 | 0·0 | 10 | −·06 | −0·8 | −0·1 |
| Nov. 8 | −·06 | −0·9 | 0·0 | 18 | −·07 | −1·0 | −0·2 |
| 16 | −·07 | −1·0 | +0·1 | 26 | −·05 | −0·7 | −0·3 |

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*Experimental Reduction of some Photographs of Eros made at the Cambridge Observatory for the Determination of the Solar Parallax.* By Arthur R. Hinks, M.A.

1. The long series of photographs of the planet *Eros* which I obtained last winter with the new Sheepshanks equatorial of the Cambridge Observatory was very much interrupted by bad weather. My programme was to make four exposures on the planet every hour between $6^h$ E. and W.—the construction of the instrument precludes greater hour-angles—and, of each set of four, two were made following the stars and letting the planet trail, two following the planet and letting the stars trail. There was only one case of two consecutive nights clear, or nearly so, right through, viz. 1900 November 9 and 10, and the plates taken on these nights, when the planet was but little past opposition, and the parallax factor had become fairly large, were clearly indicated as the subject of preliminary and experimental reductions. The plates were to be centered for each night on the position of the planet at Berlin midnight, the epoch of Professor Millosevich's ephemeris; but, by an accident very fortunate for our present purpose, the plates on the 9th were set to a centering very near that proper to the 10th, and the mistake was discovered in time to use the same point for the latter plates, so that all the exposures to be here treated have approximately the same centering on the sky.

2. As many as twenty exposures were made on one plate, the displacement necessary between each being given to the plate-carrier on rectangular slides on the breach-piece of the telescope, not by displacement of the pointing of the telescope on the sky. There is an obvious advantage in this, that the centre of projection remains unchanged, and all the exposures can be made comparable by linear formulæ of reduction, which is not strictly the case when the pointing of the telescope is changed.

3. The stars on the plates whose meridian places are known are not very symmetrically distributed about the locus of the planet, and many of them are inconveniently bright. It was necessary to consider the possibility of a systematic error due to the trail of either stars or planet—the motion of the planet was

more than a second of arc per minute—and if this exists it is almost necessarily a function of the magnitude. I selected, therefore, fourteen comparison stars well distributed about the locus of the planet, and of magnitudes as nearly as possible equal to it. These fourteen stars were measured with the planet on each exposure, with the new measuring machine which I have recently described (*Monthly Notices*, 1901 May). I may take this opportunity of saying that in accuracy, rapidity, and pleasure of use the machine has more than come up to expectation.

4. *Search for a systematic error due to trail.*—Each set of four exposures was arranged thus :—

$a$ . . $3^m$, $b$ . . $2^m$, stars fixed ; $c$ . . $3^m$, $d$ . . $2^m$, planet fixed.

A preliminary comparison showed that for any exposure the differences $b-a$ and $d-c$ for the fourteen comparison stars varied only accidentally from a constant ; they could not be represented by a linear function of the coordinates of the stars ; that is to say, during the short intervals the variations in differential refraction, orientation, &c., were insensible. In all that follows I have used the means of pairs, $\frac{1}{2}(a+b)$ and $\frac{1}{2}(c+d)$, as single exposures.

Next, an examination of the differences $\frac{1}{2}\overline{c+d}-\frac{1}{2}\overline{a+b}$ gave a similar result ; they could not be represented by a linear expression. But they ought to show an effect of error due to trail varying with the magnitude—if this error exists, indeed, at all. To examine this point, four fainter stars, whose images were barely measurable, were added to the above list of fourteen and measured on all the plates. For each of thirteen sets of four exposures the differences $\frac{1}{2}\overline{c+d}-\frac{1}{2}\overline{a+b}$ were formed, their mean taken, and the values of mean—individual found. Then, taking the mean of the thirteen results for each star, we have :

| | B D. | Mean Residual. | | B.D. | Mean Residual. |
|---|---|---|---|---|---|
| | ° | | | ° | |
| 1 | +54 434 | −2 | 10 | +54 449 | + 1 |
| 2 | 54 435 | −3 | 11 | 53 444 | + 1 |
| 3 | 54 438 | −1 | 12 | 54 451 | − 1 |
| 4 | 54 439 | −3 | 13† | 54 454 | − 1 |
| 5 | 54 442 | −1 | 14† | Anon. | +11 |
| 6† | 54 443 | −2 | 15 | Anon. | − 3 |
| 7 | Anon. | 0 | 16 | 54 459 | − 2 |
| 8 | 54 445 | −3 | 17† | 53 449 | + 4 |
| 9 | 53 441 | −1 | 18 | 54 461 | − 1 |

It does not seem worth while to add the visual magnitudes. The four stars, photographically fainter, which were added to the original fourteen are distinguished by a dagger. The

..., B, planet fixed—separa
The four faint stars, 6, 13, 14, 17, employed.

5. *Probable error of a measure.*—Inc from this discussion, if we assume that tl and $\frac{1}{2}\overline{d+c}-\frac{1}{2}\overline{b+a}$ are entirely acciden systematic error depending on trail, an e measure on a single-star disc, *including t of the apparent centre of the photograp* measure includes two settings on the st positions of the plate differing in orien results are :—

| | From $b-a$. |
|---|---|
| P.E. of a complete measure in $\xi$ | $\pm^{R}$·00053 |
| P.E. of a complete measure in $\eta$ | ± ·00048 |

$0^{R}0001=0''\cdot0175$. We may take as the one image in $\xi$ $\pm0''\cdot10$, in $\eta$ $\pm0''\cdot08$.

6. *Reduction of all the plates to stan* symmetrically arranged comparison stars we a strong means of comparing the plates i symmetry of their arrangement, they had tl equality in magnitude to the planet. Two " chosen, one for each series, A and B, taken November 10, and all the others were fi with these zero exposures. Following Turn parison by linear formulæ, equations of con the usual pattern :

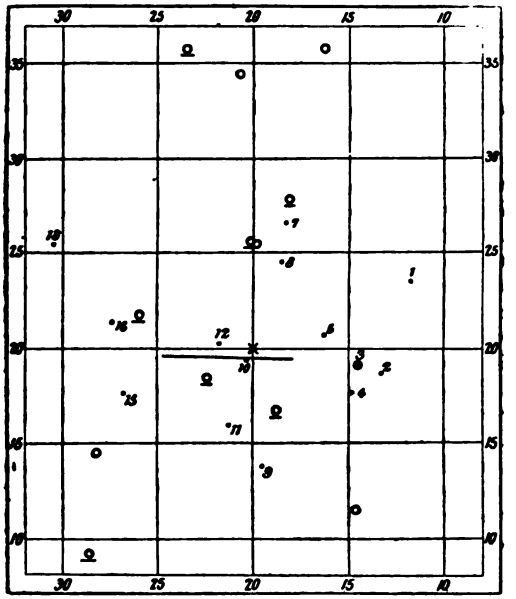
$$a\xi+b\eta+c+\xi-\xi'=0$$
$$d\xi+e\eta+f+\eta-\eta'=0$$

and for each ...

themselves, but affected still with the differential refraction and aberration, errors of orientation, scale-value, and centering of the zero exposures. On these two exposures only I have measured the images of all the stars on the plate which were to be found in the Harvard A. G. Zone Catalogue—there were scarcely enough stars in the Paris list, nor were they well distributed (see figure). The rectangular coordinates of these standard stars were computed for 1900·0 with assumed centre of plate

$$\alpha \quad 1^h\ 57^m\ 8^s \qquad \delta + 54^\circ\ 22'{\cdot}0$$

and the six constants to reduce each zero exposure to standard were found as above.




Centre of plate (1900·0) $\alpha$ $1^h\ 57^m\ 8^s$ $\delta + 54^\circ\ 22'{\cdot}0$.
• Comparison star. ——— Path of planet.
o Standard star; underlined o if in Paris list.
Half scale. Every fifth R. line only shown. 5R. = 14′·6.

The reduction of all the exposures to standard for 1900·0 proceeded, therefore, in two steps:

(1) Each exposure was reduced to the zero of its series by the aid of constants derived from the fourteen comparison stars.

(2) All were then reduced from zero to standard by the constants derived from the thirteen meridian standard stars (of which only two had served also as comparison stars).

The advantages of this double procedure seem to me to be as

follows :—In addition to the fact that the comparison stars are well distributed, and nearly equal to the planet in magnitude, we have the further advantage that there is no question of meridian places in the first step. The exposures are made comparable with one another by a process that may be considered final. No revision of meridian places can affect it. On the other hand, the reduction from zero to standard depends on the accuracy of the coordinates of the standard stars calculated from their meridian places; it may well have to be revised when better places are available. When this is done there will be only two sets of equations to solve again, instead of twenty-six.

I do not, however, anticipate that any revision of meridian places will seriously alter my constants for the reduction to standard, except perhaps the errors of centering $c$ and $f$, which will be affected by the systematic difference between the fundamental systems of Auwers and Newcomb. The average residuals in the reduction of the thirteen standard stars are in $\xi$ 0″·52 and in $\eta$ 0″·44, which speaks well for the original accuracy of the Harvard places, affected as they are now by unknown proper motions for about twenty-five years.

7. *Search for evidence of the effect of atmospheric dispersion.*—The possibility of systematic error due to atmospheric dispersion is an objection that will be alleged against the determination of the solar parallax by photography. To this may be added in the present case the possibility of variable distortion due to flexure of the plane mirror of the Cambridge equatorial varying with the hour-angle. The two effects may here be included in the category "hour-angle error" as used by Kapteyn. It is possible to find in the reduction of all the exposures to a zero near the meridian a little evidence on this matter. In series A I have taken six exposures, three on each side of the meridian, and formed for each star the differences of the reduced values of $\xi$ from the values on the zero exposure. They are given in the following table, the unit as before being the ten-thousandth of a réseau interval.

| | East. | | | West. | | | |
|---|---|---|---|---|---|---|---|
| Hour-Angle. | $-4^h{\cdot}9$. | $-4^h{\cdot}0$. | $-2^h{\cdot}9$. | $+2^h{\cdot}9$. | $+4^h{\cdot}0$. | $+4^h{\cdot}9$. | $\frac{1}{2}(\Sigma W-\Sigma E)$. |
| Star 1 | 0 | − 5 | − 3 | + 2 | 0 | + 3 | + 4 |
| 2 | + 5 | − 2 | − 9 | − 5 | + 3 | + 2 | + 3 |
| 3 | − 4 | + 6 | + 2 | +10 | + 4 | + 1 | + 4 |
| 4 | − 1 | + 4 | + 7 | + 2 | − 4 | + 3 | − 3 |
| 5 | + 2 | + 1 | + 4 | + 5 | + 2 | + 6 | + 2 |
| 7 | −12 | −11 | −13 | −11 | −12 | −14 | 0 |
| 8 | + 2 | + 1 | 0 | − 2 | − 3 | − 2 | − 3 |
| 9 | + 8 | + 6 | +11 | 0 | + 9 | 0 | − 5 |
| 10 | − 6 | −11 | −11 | + 5 | − 4 | + 2 | +10 |
| 11 | + 4 | 0 | + 2 | + 1 | + 2 | +12 | + 3 |

| | East. | | | West. | | | |
|---|---|---|---|---|---|---|---|
| Hour-Angle. | $-4^h\cdot9$. | $-4^h\cdot0$. | $-2^h\cdot9$. | $+2^h\cdot9$. | $+4^h\,0$. | $+4^h\cdot9$. | $\frac{1}{3}(\Sigma W-\Sigma E)$. |
| Star 12 | + 1 | − 7 | + 4 | − 1 | + 1 | − 7 | − 2 |
| 15 | − 5 | + 4 | − 7 | −11 | − 11 | −13 | − 9 |
| 16 | 0 | − 4 | + 7 | + 7 | +10 | + 1 | + 5 |
| 18 | + 8 | +17 | + 5 | − 1 | + 2 | + 5 | − 8 |

If a star is extra blue its $\xi$ is increased W. and diminished E.; the above residuals are algebraically diminished W. and increased E., so that the value of W.—E. (which is independent of the errors of measurement on the zero plate, except in so far as they affect the constants of reduction) is negative for an extra blue star. Taking the P.E. of a single measure in $\xi$ as 6, the probable value of a quantity in the last column, allowing a little for accumulated errors in the reduction to zero, will be about 4—it must be remembered that each residual represents the mean of two exposures. Of the fourteen quantities in the last column, five are above 4, two equal to it, and seven below 4. There is, therefore, no indication that these quantities are other than purely accidental. The evidence is slight, but it is at least in the right direction.

8. *Reduced measures of the planet.*—The following table contains the mean epoch of exposure, expressed in decimals of a day from Berlin mean noon—called afterwards T+ΔT—the measured coordinates of the planet (means of *a* and *b* or of *c* and *d*), the same reduced to zero, and then to standard, and finally these last referred to the centre of the plate (20·0 20·0) as origin, and multiplied by the constant ·00085221 to express them in terms of the radius of projection.

TABLE I.

*Measures of the planet.*

| | Series A. d. | Measures. $\xi$ and $\eta$ | Red. to Zero. | Red. to Standard. | In parts of Radius. |
|---|---|---|---|---|---|
| 1 | Nov. 9·552382 | 24·8337 | 24·6146 | 24·5935 | +·00391463 |
| | | 19·9144 | 19·7026 | 19 6764 | −·00027578 |
| 2 | ·605387 | 24·4737 | 24·2663 | 24·2453 | +·00361789 |
| | | 19·9812 | 19·6846 | 19·6564 | −·00029282 |
| 3 | ·649279 | 24·2036 | 23·9821 | 23·9612 | +·00337577 |
| | | 20·1298 | 19·6663 | 19·6365 | −·00030978 |
| 4 | ·688555 | 23·9549 | 23·7352 | 23·7144 | +·00316545 |
| | | 20·1703 | 19 6461 | 19·6149 | −·0003281 |
| 5 | ·729413 | 23·7058 | 23·4828 | 23·4621 | +·00295044 |
| | | 20·2200 | 19·6207 | 19·5880 | −·00035111 |
| 6 | 10·277103 | 20·2625 | 20·2907 | 20·2704 | +·00023044 |
| | | 19·8577 | 19·5107 | 19·4596 | −·00046053 |

| | | | | |
|---|---|---|---|---|
| -- | 5·5599 | 18·9717 | 18·7358 | 1 |
| | | 19·4730 | 19·4724 | |
| 11 | ·565637 | 18·6214 | 18·4073 | 1 |
| | | 19·5340 | 19·4453 | |
| 12 | ·605862 | 18·3782 | 18·1460 | 1 |
| | | 19·6375 | 19·4182 | |
| 13 | ·650159 | 18·0889 | 17·8614 | 17 |
| | | 19·7751 | 19·3849 | |
| | Series B. | | | |
| 1 | Nov. 9·556968 | 24·6744 | 24·4636 | 24 |
| | | 19·9127 | 19·6972 | 1 |
| 2 | ·609456 | 24·3153 | 24·1187 | 24 |
| | | 19·9880 | 19·6793 | 1 |
| 3 | ·653376 | 24·0454 | 23·8368 | 23 |
| | | 20·1384 | 19·6605 | 1 |
| 4 | ·693284 | 23·7892 | 23·5845 | 23·6 |
| | | 20·1689 | 19·6388 | 1 |
| 5 | ·733597 | 23·5449 | 23·3372 | 23·4 |
| | | 20·2229 | 19·6170 | 1 |
| 6 | 10·281374 | 20·1128 | 20·1415 | 20·2 |
| | | 19·8306 | 19·5071 | 1 |
| 7 | ·322405 | 19·8471 | 19·8811 | 19·9 |
| | | 19·7276 | 19·5089 | 1 |
| 8 | ·361507 | 19·6090 | 19·6310 | 19·7 |
| | | 19·6030 | 19·5080 | 1 |
| 9 | ·468533 | 18·9275 | zero | 19·0 |
| | | 19·4876 | expesure | 1 |
| 10 | ·510522 | [illegible] | | |

9. *Comparison with the ephemeris. General considerations.*— We are now in a position to compare with the ephemeris, and here we come to the essential point of what I have called this experimental reduction. It was suggested by Mr. Cowell in *The Observatory* (1900 December) that there are clear advantages in using in astrographic methods a heliocentric ephemeris of the planet expressed in rectangular coordinates. He points out that the reduction of the measured positions of stars and planet to standard, by the linear transformations, corrects both stars and planet completely for the aberration of light (excepting a small term depending on the eccentricity of the Earth's orbit). For the planet this is over-correction, inasmuch as the usual method of allowing for the motion of the planet during the time the light is on its way from it to us, is to leave it uncorrected for the aberration of light and to antedate the observation by the light-time. We thus obtain the true position of the planet at the antedated time, freed from both planetary aberration and the aberration of light. If, however, we correct automatically the planet with the stars for the aberration of light, we obtain the position of the planet at the time the light left it as seen from the Earth at the time the light reached it; and this is not immediately comparable with the ephemeris in its ordinary form. This difficulty is evaded if we proceed in the following manner, for the idea of which I must acknowledge my indebtedness to Mr. Cowell's paper.

10. Let the unit of distance be the mean distance of the Earth from the Sun, and let U, V, W be the heliocentric coordinates of the planet at the epoch T (the time the light left it) referred to three rectangular axes, S$u$, S$v$, S$w$. S is the centre of the Sun; the positive directions of the axes are S$u$ towards the vernal equinox for 1900·0; S$v$ in the plane of the mean ecliptic for this epoch, at right angles to S$u$, towards Cancer; S$w$ towards the north pole of the ecliptic.

Now let $f$, $g$, $h$ be the heliocentric coordinates referred to the same axes of the centre of the Earth at epoch $T+\Delta T$ (the time when the light which left the planet at T reaches the Earth). Transform to parallel axes through the centre of the Earth, E.

$U-f$, $V-g$, $W-h$, are the coordinates of the planet at epoch T as seen from the centre of the Earth E at epoch $T+\Delta T$. (System I.)

Now transform to a new set of axes through the same origin E$x$, $y$, $z$; E$z$ is drawn through the point on the celestial sphere corresponding to the assumed centre of the plate for 1900·0; E$y$ is at right angles to this in the plane of the meridian of the plate; E$x$ is at right angles to the others. E$x$, E$y$ are then parallel to the axes of coordinates on the standard plate. (System II.)

If $\alpha$, $\delta$ is the assumed centre of the plate, the direction cosines of the axes of System II. referred to the axes of System I. are easily found to be

$$l_1 = -\sin\alpha \qquad m_1 = -\sin\delta\cos\alpha \qquad n_1 = \cos\delta\cos\alpha$$

$$l_2 = \cos\varepsilon\cos\alpha \qquad m_2 = \sin\varepsilon\cos\delta - \cos\varepsilon\sin\delta\sin\alpha \qquad n_2 = \sin\varepsilon\sin\delta + \cos\varepsilon\cos\delta\sin\alpha$$

$$l_3 = -\sin\varepsilon\cos\alpha \qquad m_3 = \cos\varepsilon\cos\delta + \sin\varepsilon\sin\delta\sin\alpha \qquad n_3 = \cos\varepsilon\sin\delta - \sin\varepsilon\cos\delta\sin\alpha.$$

And with respect to the axes of System II. the coordinates of the planet at epoch T, as seen from E at epoch $T+\Delta T$, are

$$x = l_1(U-f)+l_2(V-g)+l_3(W-h) = L$$
$$y = m_1(U-f)+m_2(V-g)+m_3(W-h) = M$$
$$z = n_1(U-f)+n_2(V-g)+n_3(W-h) = N$$

Again, let $x_0, y_0, z_0$ be the coordinates of the Observatory O at epoch $T+\Delta T$ referred to the axes of System II. It is easily seen that in terms of the mean distance R of Earth from Sun

$$x_0 = \frac{\rho}{R}\cdot\frac{\rho'}{\rho}\cos\phi'\sin h = \pi a$$

$$y_0 = \frac{\rho}{R}\cdot\frac{\rho'}{\rho}(\sin\phi'\cos\delta - \cos\phi'\sin\delta\cos h) = \pi b$$

$$z_0 = \frac{\rho}{R}\cdot\frac{\rho'}{\rho}(\sin\delta\sin\phi' + \cos\delta\cos\phi'\cos h) = \pi c$$

where $h$ is the hour-angle of the centre of the plate, $\phi'$ the reduced latitude of the Observatory, $\rho'$ and $\rho$ the local and equatorial radii of the Earth, $\pi$ the Sun's equatorial horizontal parallax.

Transform finally to another set of axes through O, parallel to the axes of System II.

Then
$$X = L - a\pi$$
$$Y = M - b\pi$$
$$Z = N - c\pi$$

are the coordinates of the planet at epoch T as seen from the Observatory at epoch $T+\Delta T$.

And the position of the planet projected upon the ideal standard plate will be

$$\xi_0 = \frac{X}{Z} = \frac{1}{N}\left\{L - \left(a - \frac{c}{N}\right)\pi\right\} = \nu\{L - (a - c\nu)\pi\}$$

$$\eta_0 = \frac{Y}{Z} = \frac{1}{N}\left\{M - \left(b - \frac{c}{N}\right)\pi\right\} = \nu\{M - (b - c\nu)\pi\}$$

since $\pi c$ is small compared with N ; $\nu$ is written for $1/N$ to avoid fractions in the printing.

Now in forming the equations of condition we must put $\pi=\pi_0+\Delta\pi$, and it will be necessary to introduce tabular corrections to the ephemeris position of the planet—it will be assumed for the present that the heliocentric ephemeris of the Earth is sufficiently good. If these corrections are $\Delta U$, $\Delta V$, $\Delta W$, we have for the true $\xi$ coordinate of the planet

$$\begin{aligned} &L+l_1\Delta U+l_2\Delta V+l_3\Delta W-a(\pi_0+\Delta\pi)\\ &N+n_1\Delta U+n_2\Delta V+n_3\Delta W-c(\pi_0+\Delta\pi)\end{aligned}$$

$$=\nu\{L-\pi_0(a-\nu c)\}+\nu(l_1\Delta U+l_2\Delta V+l_3\Delta W)-\nu(a-c\nu)\Delta\pi$$

which we will write

$$\xi=\xi_0+\Delta\xi_0-\nu(a-c\nu)\Delta\pi$$

and similarly

$$\eta=\eta_0+\Delta\eta_0-\nu(b-c\nu)\Delta\pi$$

Hence each reduced measure $(\xi, \eta)$ of the planet gives us two equations of condition—

$$\nu(a-c\nu)\Delta\pi-\Delta\xi_0+\xi-\xi_0=0$$
$$\nu(b-c\nu)\Delta\pi-\Delta\eta_0+\eta-\eta_0=0$$

11. *The ephemerides.*—With very great kindness Professor Millosevich computed for me a heliocentric ephemeris of *Eros* for a part of the period during which it was under observation. My sincere acknowledgments are due to him for the readiness with which he undertook this indispensable part of the experiment.

This ephemeris, he writes, is founded upon the following elements :—

Osculation 1900 Oct. 31·5 B = epoch.

| | |
|---|---|
| M | 304° 24′ 49″·75 |
| $\mu$ | 2015″·23858 |
| $\phi$ | 12° 52′ 49″·93 |
| $\omega$ | 177° 39′ 8″·65 |
| $\Omega$ | 303° 30′ 42″·38 |
| $i$ | 10° 49′ 38″·03 |
| log $a$ | 0·1637867. |

These elements represent, account being taken of perturbations by *Venus*, *Earth*, *Mars*, *Jupiter*, and *Saturn*, within one second of arc, and generally within much less than that, all the normal places available between 1898 August and 1901 April.

| | | | | | |
|---|---|---|---|---|---|
| | 23 | 36 | 16 | 52·26 | |
| | 24 | 36 | 55 | 20·39 | |
| | 25 | 37 | 33 | 59·48 | |
| | 26 | 38 | 12 | 49·58 | |
| | 27 | 38 | 51 | 50·73 | |
| | 28 | 39 | 31 | 2·94 | |
| | 29 | 40 | 10 | 26·27 | |
| | 30 | 40 | 50 | 0·73 | 4 |
| | 31 | 41 | 29 | 46·52 | 4 |
| Nov. | 1 | 42 | 9 | 43·47 | 4 |
| | 2 | 42 | 49 | 51·68 | 4 |
| | 3 | 43 | 30 | 11·20 | 4( |
| | 4 | 44 | 10 | 42·04 | 38 |
| | 5 | 44 | 51 | 24·20 | 37 |
| | 6 | 45 | 32 | 17·74 | 35 |
| | 7 | 46 | 13 | 22·71 | 34 |
| | 8 | 46 | 54 | 39·11 | 32 |
| | 9 | 47 | 36 | 6·93 | 30 |
| | 10 | 48 | 17 | 46·20 | 28 |
| | 11 | 48 | 59 | 36·96 | 26 |
| | 12 | 49 | 41 | 39·19 | 24 |
| | 13 | 50 | 23 | 52·89 | 22 |
| | 14 | 51 | 6 | 18·08 | 19 |
| | 15 | 51 | 48 | 54·78 | 17 |
| | 16 | 52 | 31 | 42·99 | 14 |
| | 17 | 53 | 14 | 42·70 | |

From them the ephemerides of the planet and the Earth expressed in rectangular coordinates referred to the first set of axes, through the centre of the Sun, were constructed with seven-figure logarithm tables.

12. *Formation of the equations of condition.*—The mean epochs of the exposures $T+\Delta T$ reduced to Berlin M.T. are given in Table I.

The values of $\Delta T$, the light equation, were calculated from the values of log $\Delta$ given by Millosevich in *A.N.* No. 3660, 1, using Gill's value of the Sun's light equation $498^{s}\cdot46$. Thus T was found.

With these values of $T-0^{d}\cdot5$ (since the ephemeris of the planet is for midnight) and of $T+\Delta T$, the values of U, V, W, $f$, $g$, $h$ were interpolated. The third differences are small and somewhat irregular, owing largely, no doubt, to the use of only seven-figure tables.

The values of the nine direction cosines required (see paragraph 10) are :—

| | | |
|---|---|---|
| $l_1$ $-\cdot4891288$ | $m_1$ $-\cdot7089005$ | $n_1$ $+\cdot5081469$ |
| $l_2$ $+\cdot8001604$ | $m_2$ $-\cdot1328410$ | $n_2$ $+\cdot5848907$ |
| $l_3$ $-\cdot3471266$ | $m_3$ $+\cdot6926858$ | $n_3$ $+\cdot6322104$ |

The values of $a$, $b$, $c$ were formed with the data for the Cambridge Observatory

$$\phi' = 52^{\circ}\ 1'\ 29''\cdot2$$

$$\log \rho'/\rho = \bar{1}\cdot999078$$

It should be remarked that from this point no more logarithms were used. The whole of the rest of the calculations, as well as all the foregoing interpolations, were done on an arithmometer (the Thomas de Colmar), which calculates quantities of the form

$$l_1(U-f)+l_2(V-g)+l_3(W-h)$$

with great ease. It seems to me that this possibility of using an arithmometer almost throughout is a strong point of the method.

Table II. contains the quantities required in the formation of the equations of condition.

| | | | | |
|---|---|---|---|---|
| | | 34709 | 80505 | |
| 3 | ·147103 | 28805 | 84212 | |
| 4 | ·186380 | 23520 | 87456 | |
| 5 | ·227238 | ·8618020 | ·9490828 | |
| 6 | ·774938 | ·8544107 | ·9535828 | · |
| 7 | ·815713 | 38591 | 39163 | |
| 8 | ·854698 | 33315 | 42349 | |
| 9 | 9·961960 | 18790 | 51106 | |
| 10 | 10·013438 | 11814 | 55303 | |
| 11 | ·063477 | ·8505030 | 59380 | |
| 12 | ·103702 | ·8499575 | 62655 | |
| 13 | 10·147999 | + ·8493565 | + ·9566259 | + ·236 |

Series B.

| | | | | |
|---|---|---|---|---|
| 1 | 9·054790 | + ·8641220 | + ·9476581 | + ·237 |
| 2 | ·107279 | 34162 | 80921 | ; |
| 3 | ·151200 | 28254 | 84551 | ; |
| 4 | ·191109 | 22883 | 87846 | ( |
| 5 | ·231422 | ·8617456 | ·9491173 | ·237( |
| 6 | ·779209 | ·8543529 | ·9536177 | ·236 |
| 7 | ·820241 | 37978 | 39533 | 1 |
| 8 | ·859344 | 32686 | 42729 | 1 |
| 9 | 9·966371 | 18192 | 51466 | ( |
| 10 | 10·017362 | [illegible] | | |

*s of condition.*

| M | N | $\nu(a-c\nu)$ | $\nu(b-c\nu)$ | $\xi_0$ | $\eta_0$ |
|---|---|---|---|---|---|
| −·00010645 | +·37717714 | +0·6742 | +0·0153 | +·00391740 | −·00028288 |
| 10879 | 701534 | 1·1249 | 0·2662 | 362088 | 29990 |
| 11084 | 688159 | 1·4031 | 0·5539 | 339970 | 31770 |
| 11306 | 676194 | 1·5613 | 0·8552 | 316769 | 33652 |
| 11534 | 663763 | +1·6248 | 1·1916 | 295138 | 35702 |
| 16176 | 498432 | −1·5695 | 0·8430 | 023073 | 46730 |
| 16636 | 486228 | 1·3991 | 0·5318 | +·00001107 | 46645 |
| 17094 | 474564 | 1·1500 | +0·2762 | −·00020263 | 46792 |
| 18428 | 442538 | −0·1661 | −0·1005 | 080269 | 48789 |
| 19109 | 427188 | +0·3633 | −0·0748 | 109312 | 50737 |
| 19789 | 412302 | 0·8427 | +0·0802 | 137365 | 53236 |
| 20359 | 400352 | 1·1700 | 0·2879 | 159677 | 55662 |
| −·00021000 | +·37387197 | +1·4439 | +0·5851 | −·00183866 | −·00058662 |
| | | | | | |
| −·00010663 | +·37716314 | +0·7200 | +0·0333 | +·00389131 | −·00028414 |
| 10901 | 700292 | 1·1548 | 0·2901 | 359827 | 30151 |
| 11111 | 686905 | 1·4236 | 0·5836 | 335736 | 31969 |
| 11326 | 674752 | 1·5742 | 0·8932 | 314242 | 33869 |
| 11552 | 662492 | +1·6247 | 1·2498 | 292960 | 35998 |
| 16220 | 497153 | −1·5564 | 0·8087 | +·00020794 | 46703 |
| 16690 | 484871 | 1·3743 | 0·4996 | −·00001346 | 46654 |
| 17150 | 473178 | 1·1156 | +0·2493 | 022834 | 46828 |
| 18482 | 441223 | −0·1209 | −0·1037 | 082762 | 48920 |
| 19164 | 426025 | +0·4026 | −0·0671 | 111511 | 50919 |
| 19848 | 411021 | 0·8804 | +0·0989 | 139765 | 53475 |
| 20419 | 399077 | 1·2008 | 0·3139 | 162027 | 55936 |
| −·00021072 | +·37385815 | +1·4664 | +0·6201 | −·00186379 | −·00059007 |

| | | | | | |
|---|---|---|---|---|---|
| | [illegible] | −1 | | −3 | |
| 7 | −1·40 | −1 | | −15 | |
| 8 | −1·15 | −1 | | −10 | |
| 9 | −0·17 | −1 | | −11 | |
| 10 | +0·36 | −1 | | −14 | |
| 11 | +0·84 | −1 | | −7 | |
| 12 | +1·17 | −1 | | −2 | |
| 13 | +1·44 | −1 | | −7 | |

| | | | | | |
|---|---|---|---|---|---|
| η 1 | +0·02 | | $-1\Delta\eta_0$ | +71 | +6 |
| 2 | +0·27 | | −1 | +71 | +6 |
| 3 | +0·55 | | −1 | +79 | +7 |
| 4 | +0·86 | | −1 | +83 | +8 |
| 5 | +1·19 | | −1 | +59 | +56 |
| 6 | +0·84 | | −1 | +68 | +67 |
| 7 | +0·53 | | −1 | +73 | +72 |
| 8 | +0·28 | | −1 | +61 | +60 |
| 9 | −0·10 | | −1 | +67 | +67 |
| 10 | −0·07 | | −1 | +66 | +66 |
| 11 | +0·08 | | −1 | +69 | +69 |
| 12 | +0·29 | | −1 | +69 | +69 |
| 13 | +0·59 | | −1 | +70 | +71 |

Series B.

| | | | | | |
|---|---|---|---|---|---|
| | | | | $\pi_1$ | |
| ξ 1 | +0·72 | $\Delta\pi$ | $-1\Delta\xi_0$ | $-25\times10^{-7}$ | −4 |
| 2 | +1·15 | −1 | | −33 | −13 |
| 3 | +1·42 | −1 | | −26 | |
| 4 | +1·57 | | | | |

| | Series B. | | | $n_1$ | $n_2$ | $v$ |
|---|---|---|---|---|---|---|
| 11 | $+0\cdot88\Delta\pi$ | $-1\Delta\xi_0$ | | $-10\times10^{-7}$ | $-12\times10^{-7}=0$ | $-7\times10^{-7}$ |
| 12 | $+1\cdot20$ | $-1$ | | $-3$ | $-5$ | $-1$ |
| 13 | $+1\cdot47$ | $-1$ | | $-5$ | $-8$ | $-5$ |
| 1 | $+0\cdot03$ | | $-1\Delta\eta_0$ | $+68$ | $+60$ | $-5$ |
| 2 | $+0\cdot29$ | | $-1$ | $+72$ | $+65$ | $-1$ |
| 3 | $+0\cdot58$ | | $-1$ | $+80$ | $+71$ | $+4$ |
| 4 | $+0\cdot89$ | | $-1$ | $+74$ | $+66$ | $-2$ |
| 5 | $+1\cdot25$ | | $-1$ | $+88$ | $+82$ | $+13$ |
| 6 | $+0\cdot81$ | | $-1$ | $+67$ | $+65$ | $-3$ |
| 7 | $+0\cdot50$ | | $-1$ | $+64$ | $+63$ | $-4$ |
| 8 | $+0\cdot25$ | | $-1$ | $+61$ | $+60$ | $-6$ |
| 9 | $-0\cdot10$ | | $-1$ | $+62$ | $+62$ | $-3$ |
| 10 | $-0\cdot07$ | | $-1$ | $+70$ | $+70$ | $+5$ |
| 11 | $+0\cdot10$ | | $-1$ | $+66$ | $+67$ | $+2$ |
| 12 | $+0\cdot31$ | | $-1$ | $+61$ | $+62$ | $-4$ |
| 13 | $+0\cdot62$ | | $-1$ | $+69$ | $+70$ | $+3$ |

The numerical terms which arise from the combination of the quantities of Table II. are found in the column $n_1$. They are expressed in terms of the length of the radius of projection on to the plate; that is to say, they are independent of the focal length of the particular telescope employed, so that the equations could be combined immediately with the work of other telescopes reduced in the same way.

13. *Empirical correction of the ephemeris.*—A glance at the terms in column $n_1$ of the $\xi$ equations shows that the equations cannot be satisfied as they stand. We must introduce a correction to the ephemeris varying with the time.

An approximate value of this correction was found as follows:

Taking groups of equations of condition which have similar parallax factors on the two nights, and writing them in the form

$$a\Delta\pi+\Delta\xi_0+\Delta'\xi_0 t+n=0$$

we have from among the $\xi$ equations of Series A:

| | | | | | |
|---|---|---|---|---|---|
| 1 | $+0\cdot67$ | $\Delta\pi+\Delta\xi_0$ | $+0\cdot05$ | $\Delta'\xi_0$ | $-28=0$ |
| 2 | $+1\cdot12$ | | $+0\cdot10$ | | $-30$ |
| 3 | $+1\cdot40$ | | $+0\cdot15$ | | $-39$ |
| 11 | $+0\cdot84$ | | $+1\cdot06$ | | $-7$ |
| 12 | $+1\cdot17$ | | $+1\cdot10$ | | $-2$ |
| 13 | $+1\cdot44$ | | $+1\cdot15$ | | $-7$ |

and subtracting the mean of the first three from the mean of the second

$$0{\cdot}09\,\Delta\pi + 1{\cdot}00\,\Delta'\xi_0 + 27 = 0.$$

The effect of $\Delta\pi$ is inappreciable. Proceeding in the same way with the other groups we find that the corrections to be added to the numerical terms to allow for an error in the ephemeris varying with the time are

| | | |
|---|---|---|
| $\Delta'\xi_0 =$ | Series A $-27t$ | Series B $-22t$ |
| $\Delta'\eta_0 =$ | $+\ 4t$ | $+\ 8t$ |

Reckoning $t$ from Berlin midnight on November 10, the corrected values of the numerical terms are found in the column $n_2$ of the equations of condition.

This does not, however, necessarily represent a real correction to the assumed motion of the planet. The greater part may be due to the accumulation of error in adding two separate ephemerides each computed with seven-figure logarithm tables. The necessity for it should disappear with more accurate ephemerides. It has been used here as a temporary expedient, and it is practicable only when we have observations on two consecutive nights at the same hour-angles, which was not a common case last winter.

14. *Solution of the equations of condition.*—In this preliminary solution equal weight has been given to each equation.

The normal equations from the twenty-six equations of condition of Series A are :

$$\begin{aligned}
+22{\cdot}83\,\Delta\pi - 5{\cdot}89\,\Delta\xi_0 - 5{\cdot}33\,\Delta\eta_0 + 336{\cdot}59 &= 0\\
-\ 5{\cdot}89\,\Delta\pi + 13{\cdot}00\,\Delta\xi_0 \quad 0{\cdot}00\,\Delta\eta_0 + \ 74{\cdot}00 &= 0\\
-\ 5{\cdot}33\,\Delta\pi \quad 0{\cdot}00\,\Delta\xi_0 + 13{\cdot}00\,\Delta\eta_0 - 887{\cdot}00 &= 0
\end{aligned}$$

And their solution gives

| | | | |
|---|---|---|---|
| P.E. of one equation $\pm 4{\cdot}63$ or | | $\pm 0''{\cdot}096$ | Wt. |
| $\Delta\pi = -\ 0{\cdot}36 \pm 1{\cdot}09$ | „ | $-0''{\cdot}007 \pm 0''{\cdot}023$ | 17·97 |
| $\Delta\xi_0 = -\ 5{\cdot}85 \pm 1{\cdot}38$ | „ | $-\ 0{\cdot}12 \pm 0{\cdot}028$ | 11·32 |
| $\Delta\eta_0 = +68{\cdot}08 \pm 1{\cdot}36$ | „ | $+\ 1{\cdot}40 \pm 0{\cdot}028$ | 11·59 |

Similarly for Series B[1]:

$$\begin{aligned}
+23{\cdot}31\,\Delta\pi - 6{\cdot}26\,\Delta\xi_0 - 5{\cdot}46\,\Delta\eta_0 + 381{\cdot}65 &= 0\\
-\ 6{\cdot}26\,\Delta\pi + 13{\cdot}00\,\Delta\xi_0 \quad 0{\cdot}00\,\Delta\eta_0 + \ 87{\cdot}00 &= 0\\
-\ 5{\cdot}46\,\Delta\pi \quad 0{\cdot}00\,\Delta\xi_0 + 13{\cdot}00\,\Delta\eta_0 - 863{\cdot}00 &= 0
\end{aligned}$$

| | | | |
|---|---|---|---|
| P.E. of one equation $\pm 4{\cdot}26$ or | | $\pm 0''{\cdot}088$ | Wt. |
| $\Delta\pi = -\ 3{\cdot}40 \pm 1{\cdot}01$ | „ | $-0''{\cdot}070 \pm\ 0{\cdot}021$ | 18·00 |
| $\Delta\xi_0 = -\ 8{\cdot}33 \pm 1{\cdot}28$ | „ | $-\ 0{\cdot}17 \pm\ 0{\cdot}026$ | 11·13 |
| $\Delta\eta_0 = +64{\cdot}85 \pm 1{\cdot}25$ | „ | $+\ 1{\cdot}34 \pm\ 0{\cdot}026$ | 11·53 |

The residuals which arise from substituting these values of the unknowns in the equations of condition are given in the last column of the table. It will be noticed that the residuals in the four equations No. 5, which represent the last set of exposures on November 9, are unduly large. I have remeasured the images of the planet and examined the reductions, and can find no error. The zenith distance was about 50° and the images are bad; indeed throughout the whole of these two nights the seeing was not at all good; they were the first frosty nights of the winter.

It does not seem necessary to give the value of $\pi_0$ which has been assumed in these reductions, as it is inadvisable to multiply results which are in no sense definitive, even for the small number of observations here discussed.

15. The difference 0″·06 between the results of Series A (stars fixed) and Series B (planet fixed) looks somewhat large, though it is well within the possible difference of two results each with a P.E. ±0″·02. For the present I should prefer to look upon it as bad luck, and should deprecate the drawing of any conclusion confirmatory of the fears that have been expressed that systematic error may arise from the motion of the planet. If such error were independent of the magnitude, and a function only of the motion of the planet and the time of exposure—that is to say, of the length of the trail—each series would give a value of the parallax free from systematic error, since the time of exposure and the motion of the planet were sensibly constant for the two nights; and both would give similarly erroneous values of the tabular corrections. If the error were a function of the magnitude, which varies effectively with the zenith distance, it should nevertheless be eliminated by the method here employed of reducing by means of comparison stars very nearly equal to the planet in magnitude. Moreover some evidence has been given that, even for stars on the limit of photographic action for the particular exposure, no certain trace of the effects of trail is discoverable. I prefer then to draw no further conclusion from the discrepancy than that it will be wise to adhere to my resolution to keep the two series separate right through the work.

16. *Tabular errors of the planet.*—It is a not inconsiderable advantage of this method that we can easily derive from the values found for $\Delta\xi_0$, $\Delta\eta_0$, the corrections to the tabular heliocentric longitude and latitude of the planet, if we assume that the ephemeris of the Earth is accurate.

From the relations between U, V, W and $\lambda$, $\beta$, R, the heliocentric longitude, latitude, and radius vector, we have

$$\Delta U = \cos\beta\cos\lambda\,.\,\Delta R - R\cos\beta\sin\lambda\,.\,\Delta\lambda - R\cos\lambda\sin\beta\,.\,\Delta\beta$$

$$\Delta V = \cos\beta\sin\lambda\,.\,\Delta R + R\cos\beta\cos\lambda\,.\,\Delta\lambda - R\sin\lambda\sin\beta\,.\,\Delta\beta$$

$$\Delta W = \sin\beta\,.\,\Delta R + R\cos\beta\,.\,\Delta\beta$$

$\Delta\lambda = +\ 4{\cdot}9 + 0{\cdot}$
$\Delta\beta = +14{\cdot}7 + 0{\cdot}$

$\Delta R$ must be derived from an extende
tion of the theory of the planet's motic
present, we have $\Delta\lambda = +0''{\cdot}10$ $\Delta\beta = +$

There is, therefore, no need tc
ephemeris of the planet at any point c
the values of log $\Delta$ from Millosevich's
equation, because they were ready to h
distances of the planet are easily found

$$\Delta^2 = (U-f)^2 + (V-g)^2 +$$

17. *Conclusions.*—To sum up, I sl
following conclusions may be drawn fi
experimental reduction of a small series c

(1) The smallness of the probable ei
condition, even with a comparatively roug
omen for the ultimate success of the ente

(2) It is an absolute necessity
computed with eight-figure logarithms.
for since Sir David Gill found that it
heliometer determination of the solar
wasting time now if our results were
demand it.

(3) There is only one complete set of eig
ence—viz. those published by the French
*l'Armée*, which are based on the cent
quadrant. *We must therefore work in*
Professor Bauschinger kindly informe
Victoria for Sir D

(*a*) the ephemeris of the Earth can be computed once for all; the ephemeris of the planet can with comparatively small labour be improved from time to time as we proceed, and the corrections can be carried into our equations of condition with the minimum of trouble. (*b*) The interpolations from the heliocentric ephemerides are not so troublesome as from a geocentric; the quantities vary more regularly. (*c*) The greater part of the calculation is done on a machine instead of with logarithms, which saves a deal of writing. (*d*) The form of the work is comparatively simple, and you see clearly what you are doing all through.

(5) Since the sub-committee of the *Comité International Permanent* is publishing the revised places of the standard stars referred to Newcomb's Fundamental Catalogue, it will be necessary to refer the elements of the orbit of *Eros* to Newcomb's system—at present they are based on Leverrier's—and to compute the ephemeris of the Earth from Newcomb's tables of the Sun, with Gill's value for the mass of the Moon.

(6) Finally, the great advantage is that photographic results reduced on these lines by different observatories would be most readily available for a general combination. And the micrometric results could be easily included, for they are essentially measures in rectangular coordinates, and they might be reduced in exactly the same way.

*Cambridge Observatory:*
1901 *November* 6.

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## *The Determination of Selenographic Positions and the Measurement of Lunar Photographs.*

[Second Paper.]

*Determination of a first group of Standard Points by Measures made at the Telescope and on Photographs.* By S. A. Saunder, M.A.

### § 1. *Recapitulation of First Paper.*

In a previous paper (*Monthly Notices*, vol. lx. p. 174) I called attention to the unsatisfactory state of our knowledge of the exact positions of the lunar formations, and to the increase in accuracy which might be obtained by measuring from the well-determined point *Mösting A*; formulæ were developed for reducing the measures, and a few results were given.

It was also shown that by the measurement of such photographs as those now being taken at the Paris Observatory a great increase might be made in the number of points whose positions could be accurately determined without necessitating

plates in the same way.

Further work on the same pair howev
constants obtained ought to be capable of i
were signs of a progressive error, which I
been due to an error of scale on one of the
was not of sufficient magnitude to vitiate the
drawn in the paper. I soon became convi
satisfactory solution was likely to be obtain
part of the work depended on measures of the
to determine the plate constants by an extens
called the stereoscopic method, and when thi
described below, I had recourse to the telesc
to determine the positions of a number of
*Mösting A* at distances not much exceeding
being imposed by the construction of my micr

§ 2. *Telescopic Measures on the M*

These measures were all made and reduce
§ 3 to § 6 of the previous paper, the only chan
that, with the notation of § 4, when $\xi'$, $\eta'$, $\zeta$
measured the equation $z'=a_3\xi'+b_3\eta'+c_3\zeta'$ has
pute the value of $1-z'\sin s'$, the value of $z'$ th
always sufficiently accurate for the purpose.
been determined from the equations at the bott

$$x'=z\frac{1-z'\sin s'}{1-z\sin s'}-Q(1-z'\sin s')\sin$$

$$y'=y\frac{1-z'\sin s'}{1-z\sin s'}+Q(1-z'\sin s')\cos$$

This saves the

These measures have been of great use to me as will be explained below. The places expressed in terms of rectangular coordinates are :

| | | |
|---|---|---|
| Proclus ... | $\xi = +\cdot70222 \pm \cdot00012$ | $\eta = +\cdot27698 \pm \cdot00020$ |
| Macrobius *a* ... | $+\cdot61034 \pm 12$ | $+\cdot33455 \pm 20$ |
| Sharp A ... | $-\cdot45663 \pm 23$ | $+\cdot73763 \pm 15$ |
| Aristarchus ... | $-\cdot67551 \pm 17$ | $+\cdot40201 \pm 21$ |
| Gassendi *e* ... | $-\cdot65246 \pm 12$ | $-\cdot28330 \pm 15$ |
| Byrgius A ... | $-\cdot81612 \pm 17$ | $-\cdot41561 \pm 20$ |
| Nicolai A ... | $+\cdot29598 \pm 11$ | $-\cdot67494 \pm 14$ |
| Fabricius K ... | $+\cdot46642 \pm 16$ | $-\cdot72018 \pm 17$ |

The measures were all made with the Königsberg heliometer, and the observations extend over a period of six years. *Byrgius A* was measured on eight different nights ; the others depend each on from eleven to thirteen separate determinations.

An account of the measures of *Ptolemæus A* and *Triesnecker B*, kindly made for me by Professor Barnard, has already appeared (*Monthly Notices*, vol. lx. p. 540), together with the particulars of my own measures of these points (see also *Astronomical Journal*, vol. xxii. p. 33).

Four measures of *Dollond* are given in *Monthly Notices*, vol. lx. p. 182.

These, with *Mösting A* and those given below, complete the list of the positions used in the reduction of the photographic plates.

A complete set of measures consists, as described in § 6 of my previous paper, of six settings for position-angle, five double distances, and six more settings for position-angle. Occasionally a set has been interrupted by clouds or by failure of definition. If less than half the whole set had been made, no account has been taken of them ; if more than half, they have been reduced and allowed weight $\frac{1}{2}$ in the final means. No place depends on less than four complete sets or their equivalent.

The probable error of a coordinate derived from one complete set, as determined from the whole of the residuals, is ·00022, and hence the probable error of the mean of four such measures is ·00011, the geocentric value of which is 0″·10.

*Results of micrometric measures made on the Moon with a 7-inch O.G.*

*Hesiodus B.*

| | | $\xi$ | Residual. | $\eta$ | Residual. | Wt. |
|---|---|---|---|---|---|---|
| 1899 Dec. | 14 | $-\cdot2670 + \cdot0001 \times \frac{1}{2}$ | | $-\cdot4553 + \cdot0002 \times \frac{1}{2}$ | | $\frac{1}{2}$ |
| | 15 | $-\cdot2673 -$ | 2 | $-\cdot4554 +$ | 1 | |
| 1900 Feb. | 11 | $-\cdot2673 -$ | 2 | $-\cdot4558 -$ | 3 | |
| Nov. | 9 | $-\cdot2664 +$ | 7 | $-\cdot4554 +$ | 1 | |
| 1901 Apr. | 1 | $-\cdot2676 -$ | 5 | $-\cdot4555$ | 0 | |
| | | $-\cdot2671$ | | $-\cdot4555$ | | |

| | | | | | |
|---|---|---|---|---|---|
| 1900 Apr. | 10 | $\xi =$ | $-\cdot0785$ | $+\cdot0007$ | $\eta =$ - |
| | 13 | | $-\cdot0795$ | $-\quad3$ | - |
| May | 7 | | $-\cdot0792$ | $\quad0$ | - |
| Nov. | 10 | | $-\cdot0796$ | $-\quad4$ | - |
| | | | $-\cdot0792$ | | - |

*Abenezra b.*

| | | | | | |
|---|---|---|---|---|---|
| 1900 Sept. | 12 | $\xi =$ | $+\cdot1634$ | $-\cdot0001$ | $\eta =$ — |
| Oct. | 10 | | $+\cdot1635$ | $\quad0$ | — |
| 1901 Jan. | 31 | | $+\cdot1633$ | $-\quad2$ | — |
| Feb. | 28 | | $+\cdot1636$ | $+\quad1$ | — |
| | | | $+\cdot1635$ | | — |

*Airy A.*

| | | | | | |
|---|---|---|---|---|---|
| 1900 Sept. | 12 | $\xi =$ | $+\cdot1276$ | $\cdot0000$ | $\eta =$ — |
| Oct. | 10 | | $+\cdot1275$ | $-\quad1$ | — |
| 1901 Jan. | 29 | | $+\cdot1281$ | $+\quad5$ | — |
| Mar. | 3 | | $+\cdot1274$ | $-\quad2$ | — |
| | | | $+\cdot1276$ | | — |

*Lubiniezky B.*

| | | | | | |
|---|---|---|---|---|---|
| 1900 Apr. | 13 | $\xi =$ | $-\cdot3863$ | $\cdot0000$ | $\eta =$ —· |
| Aug. | 17 | | $-\cdot3865$ | $-\quad2$ | —· |
| Oct. | 14 | | $-\cdot3865$ | $-\quad2$ | —· |
| 1901 Jan. | 2 | | $-\cdot3861$ | $+\quad2$ | —· |
| | | | $-\cdot3863$ | | —· |

*Euclides.*

| | | | Residual. | | Residual. |
|---|---|---|---|---|---|
| 1899 | Dec. 13 | $\xi = -\cdot4886$ | ·0000 | $\eta = -\cdot1279$ | +·0004 |
| | 15 | $-\cdot4887$ | − 1 | $-\cdot1283$ | 0 |
| 1901 | Feb. 11 | $-\cdot4883$ | + 3 | $-\cdot1283$ | 0 |
| | Nov. 10 | $-\cdot4888$ | − 2 | $-\cdot1286$ | − 3 |
| | | $-\cdot4886$ | | $-\cdot1283$ | |

*Hipparchus G.*

| | | | | | |
|---|---|---|---|---|---|
| 1900 | Nov. 9 | $\xi = +\cdot1289$ | +·0002 | $\eta = -\cdot0871$ | +·0004 |
| | 10 | $+\cdot1290$ | + 3 | $-\cdot0871$ | + 4 |
| 1901 | Jan. 4 | $+\cdot1285$ | − 2 | $-\cdot0880$ | − 5 |
| | Feb. 1 | $+\cdot1284$ | − 3 | $-\cdot0878$ | − 3 |
| | | $+\cdot1287$ | | $-\cdot0875$ | |

*Gambart A.*

| | | | | | |
|---|---|---|---|---|---|
| 1900 | Mar. 12 | $\xi = -\cdot3205$ | +·0005 | $\eta = +\cdot0173$ | +·0003 |
| | 13 | $-\cdot3211$ | − 1 | $+\cdot0170$ | + 0 |
| | Apr. 10 | $-\cdot3210$ | 0 | $+\cdot0171$ | + 1 |
| | Nov. 9 | $-\cdot3214$ | − 4 | $+\cdot0167$ | − 3 |
| | | $-\cdot3210$ | | $+\cdot0170$ | |

*Cayley.*

| | | | | | |
|---|---|---|---|---|---|
| 1900 | Aug. 12 | $\xi = +\cdot2599$ | −·0004 | $\eta = +\cdot0691$ | +·0001 |
| | 13 | $+\cdot2603$ | 0 | $+\cdot0691$ | + 1 |
| 1901 | Jan. 30 | $+\cdot2604$ | + 1 | $+\cdot0689$ | − 1 |
| | Feb. 28 | $+\cdot2606$ | + 3 | $+\cdot0690$ | 0 |
| | | $+\cdot2603$ | | $+\cdot0690$ | |

*Hortensius.*

| | | | | | |
|---|---|---|---|---|---|
| 1900 | Aug. 17 | $\xi = -\cdot4662$ | ·0000 | $\eta = +\cdot1127$ | −·0001 |
| | Oct. 14 | $-\cdot4662$ | 0 | $+\cdot1128$ | 0 |
| 1901 | Jan. 2 | $-\cdot4657$ | + 5 | $+\cdot1134$ | + 6 |
| | 30 | $-\cdot4664$ | − 2 | $+\cdot1122$ | − 6 |
| | 31 | $-\cdot4666$ | $-4\times\frac{1}{2}$ | $+\cdot1127$ | $-1\times\frac{1}{2}$ Wt. $\frac{1}{2}$ |
| | | $-\cdot4662$ | | $+\cdot1128$ | |

*Sosigenes a.*

| | | | | | |
|---|---|---|---|---|---|
| 1900 | Nov. 10 | $\xi = +\cdot3141$ | $-\cdot0004\times\frac{1}{2}$ | $\eta = +\cdot1357$ | $+\cdot0008\times\frac{1}{2}$ Wt. $\frac{1}{2}$ |
| | Dec. 29 | $+\cdot3149$ | $+4\times\frac{1}{2}$ | $+\cdot1353$ | $+4\times\frac{1}{2}$ Wt. $\frac{1}{2}$ |
| 1901 | Jan. 29 | $+\cdot3147$ | + 2 | $+\cdot1348$ | − 1 |
| | Feb. 28 | $+\cdot3145$ | 0 | $+\cdot1346$ | − 3 |
| | Mar. 3 | $+\cdot3143$ | − 2 | $+\cdot1346$ | − 3 |
| | | $+\cdot3145$ | | $+\cdot1349$ | |

*Bode A.*

| | | | | | | |
|---|---|---|---|---|---|---|
| 1899 | Dec. | 15 | $\xi =$ | $-\cdot0203$ | $-\cdot0004$ | $\eta =$ |
| 1900 | Mar. | 9 | | $-\cdot0194$ | $+\ 5$ | |
| | | 12 | | $-\cdot0198$ | $+\ 1$ | |
| | | 13 | | $-\cdot0200$ | $-\ 1$ | |
| | | | | $-\cdot0199$ | | |

*Bessel.*

| | | | | | | |
|---|---|---|---|---|---|---|
| 1900 | Aug. | 12 | $\xi =$ | $+\cdot2853$ | $-\cdot0003$ | $\eta = +$ |
| | | 13 | | $+\cdot2852$ | $-\ 4$ | $+$ |
| 1901 | Jan. | 2 | | $+\cdot2855$ | $-\ 1$ | $+$ |
| | | 4 | | $+\cdot2864$ | $+\ 8$ | $+$ |
| | Apr. | 1 | | $+\cdot2856$ | $0$ | $+$ |
| | | | | $+\cdot2856$ | | $+$ |

§ 3. *Attempt to determine Absolute Places of two Photographs only.*

The unsuccessful attempt to improve tl plates denoted by the numbers II., III. in m which I referred in my first paragraph, was i

The standard coordinates of a point with the plate coordinates $x$, $y$ and tl $z=\sqrt{1-x^2-y^2}$, as shown in *Monthly Noti* by the equations

$$\xi = Ax + By + Cz$$
$$\eta = Dx + Ey + Fz$$

But errors may also have been made in $\alpha'$ $\beta'$, the assumed réseau coordinates of the centre of the Moon's disc, and in $r'$, the assumed value of the radius, also in réseau units. Let $\delta\alpha'$, $\delta\beta'$, $\delta r'$ be the amounts of these errors in réseau units; $\delta\alpha$, $\delta\beta$, $\delta r$ the same quantities expressed in terms of the Moon's radius.

Let $x'$, $y'$ be the réseau coordinates of the point as actually read, *i.e.* referred to one corner of the réseau as origin.

Then
$$x=\frac{x'-\alpha'}{r'}, \quad y=\frac{y'-\beta'}{r'}$$

$$\therefore \delta x=\frac{-r'\delta\alpha'-(x'-\alpha')\delta r'}{r'^2}$$

$$=-\frac{\delta\alpha'}{r'}-\frac{x'-\alpha'}{r'}\frac{\delta r'}{r'}$$

$$=-\delta\alpha-x\delta r$$

Similarly
$$\delta y=-\delta\beta-y\delta r$$

And since
$$z=\sqrt{1-x^2-y^2}$$

$$\therefore \delta z=-\frac{x\delta x+y\delta y}{z}$$

$$=\frac{x}{z}\delta\alpha+\frac{y}{z}\delta\beta+\frac{1-z^2}{z}\delta r$$

And hence

$$\delta\xi=A\delta x+B\delta y+C\delta z+(Bx-Ay)\delta\theta$$

$$=\left(C\frac{x}{z}-A\right)\delta\alpha+\left(C\frac{y}{z}-B\right)\delta\beta+\frac{C}{z}\delta r-(Ax+By+Cz)\delta r$$
$$+(Bx-Ay)\delta\theta$$

$$=\left(C\frac{x}{z}-A\right)\delta\alpha+\left(C\frac{y}{z}-B\right)\delta\beta+\left(\frac{C}{z}-\xi\right)\delta r+(Bx-Ay)\delta\theta$$

Similarly

$$\delta\eta=\left(F\frac{x}{z}-D\right)\delta\alpha+\left(F\frac{y}{z}-E\right)\delta\beta+\left(\frac{F}{z}-\eta\right)\delta r+(Dx-Ey)\delta\theta$$

To determine these corrections thirty-seven points were measured on each of the two plates, the measures were reduced with the approximate values of $\alpha'$, $\beta'$, $r'$, and $\theta$ already obtained, and then thirty-seven equations were made of the type

$$\xi_2+\delta\xi_2=\xi_3+\delta\xi_3$$

and thirty-seven of the type

$$\eta_2+\delta\eta_2=\eta_3+\delta\eta_3$$

... the next equation left to
according to the order of elimination, s
which would be given by the solution
weight, whilst on pushing to a numerical
centre was obtained which was known to
thing like three seconds of arc.

The reason for this may be seen by
the normal equations ; if, for example, we
these, as written in the usual form, were

$$37{\cdot}0643\delta a_2 - 36{\cdot}1251\delta a_3 + {\cdot}1831\delta\beta_2 + 9{\cdot}3175$$
$$+ 1{\cdot}8799\delta\theta_3 - 2{\cdot}7882\delta r_2 - 5{\cdot}$$
$$-36{\cdot}1251\delta a_2 + 37{\cdot}7490\delta a_3 - 9{\cdot}8515\delta\beta_2 + {\cdot}25$$
$$- {\cdot}5903\delta\theta_3 + 2{\cdot}9563\delta r_2 + 6{\cdot}$$

If we put $\delta a_2 + \delta a_3 = 2A$, $\delta a_2 - \delta a_3 = 2a$,
become

$$9392A + 73{\cdot}1894a \text{ in the first}$$
$$1{\cdot}6239A - 73{\cdot}8741a \text{ in the seco}$$

whence we see that while the differences
the sums have very small coefficients ; and
for all the pairs of normal equations.

The interpretation is that the unavoida
tion were such that the difference betwe
not sufficient to give more than a rough a
absolute values of the required constants.

§ 4. *Formation of Equations by Combinat*
*and Photographic Measur*

The work, however, was not entirely lost
elimination when only half effected it was

where P, Q, R . . . were obtained numerically, and the probable errors are expressed in terms of the Moon's radius, the geocentric value of the largest being 0″·06.

These equations were used to transform the linear equations

$$\delta\xi_2=F(\delta a_2,\ \delta\beta_2,\ \delta\theta_2,\ \delta r_2) \qquad \delta\eta_2=f(\delta a_2,\ \delta\beta_2,\ \delta\vartheta_2,\ \delta r_2)$$

found in § 3 into equivalent linear equations

$$\delta\xi_2=F_1(\delta a_3,\ \delta\beta_3,\ \delta\vartheta_3,\ \delta r_3) \qquad \delta\eta_2=f_1(\delta a_3,\ \delta\beta_3,\ \delta\vartheta_3,\ \delta r_3)$$

in which the coefficients are functions of the position of the point $\xi$, $\eta$, as well as of the constants P, Q, R . . .

With these equations measures made upon Plate II. could be used to determine the corrections to the constants of Plate III., and as Plate II. was taken a little after first quarter, Plate III. a little before third quarter, the two together show the whole disc, with a slight overlap near the central meridian.

But in order to find these corrections it was necessary to know the positions of a number of points on the Moon's surface, and it had already been shown (*Monthly Notices*, vol. lx. p. 184) that those previously found as "points of the first order" were not good enough for the purpose. It was at this stage that use was made of the places found at the telescope.

The available material consisted of the positions of *Mösting A*, from which all the others had been measured, 19 points within about 500″ of *Mösting A* measured by myself, two of which had been also measured by Professor Barnard, and the 8 points, all near the limb, measured by Dr. Franz. Two of these 8, *Aristarchus* and *Byrgius A*, were, in consequence of the brightness of the surrounding regions, too poorly defined to be measurable on the photographs. I had therefore a total of 26 points, of which 8 appeared on Plate II. only, 8 on Plate III. only, and 10 were shown on both plates. These were all the centres of regular circular formations. I had also measured the cones of *Herschel* and *Manilius*, but in consequence of the difficulty in locating the summit of a mountain I decided not to employ any points of this nature.

The selected points having been carefully measured on the photographs, the corresponding values of $\xi$, $\eta$ were computed for each, as well as the coefficients of the different terms in the expressions for $\delta\xi$, $\delta\eta$, the approximate values of the plate constants being used for the purpose.

Equating the values of $\xi+\delta\xi$, $\eta+\delta\eta$ found from the photographs to the corresponding values of $\xi$, $\eta$ found at the telescope, there were 72 equations for the four quantities $\delta a_3$, $\delta\beta_3$, $\delta r_3$, $\delta\vartheta_3$. But these were not all dealt with in one group.

micrometer screw had begun
evidenced by a want of constancy of the err
parts of the scale, and I felt anxious as to
this upon the measures.

I therefore picked out the 60 conditio
from the positions of *Mösting A* and of th
measured myself, and from these determin
the plate constants.

I then dealt in the same way with the 1(
from the positions of *Mösting A* and of the
Dr. Franz.

The following table shows the results
The values of $\delta a_3$, $\delta\beta_3$, $\delta r_3$ are expressed fi
Moon's radius as unit, and secondly in secor
distance of the Moon ; $\delta\theta_3$ is expressed first
and secondly in seconds of arc.

| | $\delta a_3$ | $\delta\beta_3$ |
|---|---|---|
| Difference between absolute values of corrections found from the two groups of equations ... | ·00023 = 0″·21 | ·00022 = 0″·2 |
| P.E. from measures by S. A. S ... | ·00005 = 0·05 | ·00005 = 0·0 |
| P.E. from measures by J. F. ... | ·00011 = 0·10 | ·00010 = 0·0 |

The first point to which attention was di
differences between the values of $\delta a_3$, $\delta\beta_3$ we
sum of the probable errors, whilst the probab
own points were about half those from Dr. F
fact that my values depended on nearly fo
conditional equations would explain the diff
error, but the difference in the values found
to the fact that the points which I had measu
were more clearly defined on the photograph
Dr. Franz had measured.

that the centre would be best determined by considering only the equations of the first group.

The want of definition of Dr. Franz's points upon the photographs would also affect the values of the radius and orientation derived from them; but this was compensated by their greater distance from the centre, and the probable errors from the two groups were practically the same. But in the normal equations for $\delta r_3$ the coefficient of $\delta a_3$ was nearly as great as that of $\delta r_3$. This was found to be due, as to *Mösting A* and the points which I had measured, to a relation between the libration and the position of the terminator in consequence of which the coefficients of $\delta a_3$, $\delta r_3$ retained the same sign in all the equations of the $\xi$ group given by Plate II. As to the points measured by Dr. Franz the fact that four of them were on one side of the central meridian and only two of them on the other operated in the same way. The result was that the value found for $\delta r_3$ depended largely upon that assigned to $\delta a_3$, whilst the normal equation for $\delta a_3$ was such that the value of $\delta a_3$ was only slightly affected by that of $\delta r_3$. When this was noticed the normal equations in $\delta r_3$, $\delta\theta_3$ given by my points and those given by Dr. Franz's points were solved with the same values of $\delta a_3$, $\delta\beta_3$. The difference between the two values found for $\delta r_3$ was then reduced to ·00015 of the Moon's radius=0″·14. The difference in the scales derived from the two sets of measures amounted therefore to but little more than one part in 7,000, with which agreement I was quite satisfied, and from which it would appear that the wear of the screw had not been sufficient to introduce sensible error into the results.

The two values of $\delta\theta_3$ were practically coincident, though the probable errors show that this was partly fortuitous.

## § 6. *Final Solution of the Equations.*

Having decided that the whole 72 equations should be employed in the determination of $\epsilon r_3$, $\epsilon\theta_3$, whilst the values of $\epsilon a_3$, $\epsilon\beta_3$ should depend upon the group of 60 only, the proper course would have been to express $\delta r_3$, $\epsilon\theta_3$ as functions of $\delta a_3$, $\epsilon\beta_3$ from the 72 equations, to substitute these values in the group of 60, and to solve the resulting equations for $\delta a_3$, $\epsilon\beta_3$. This, however, would have involved a considerable addition to the labour of computation, which was already very great, whilst the effect upon the solution would have been almost imperceptible. The greatest difference between the solutions obtained entirely from one set or entirely from the other set of equations amounted only to 0″·2. I therefore compromised matters by taking the two normal equations in $\epsilon a_3$, $\epsilon\beta_3$ from the group of 60 conditional equations, the two in $\delta r_3$, $\delta\theta_3$ from the whole group of 72, and accepted as final the values resulting from their simultaneous solution.

ditional equation, and so have less weight in
than the others. But I believe that the pr
sent are in the photographic measures, and
course adopted is justifiable.

The advantages which would seem to b
ing the constants of one plate in terms of t
first that a greater number of conditional e
than could be secured from either plate alon
the use of two plates taken under different

*Comparison between Places derived from .*

| | Values of | | | |
|---|---|---|---|---|
| | Plate II. | Plate III. | II.–III. | Me II. |
| Lilius (sm. crater)* | +·0617 | +·0620 | −·0003 | +·( |
| Licetus (sm. crater)† | +·0231 | +·0221 | + 10 | +·( |
| Fabricius K | +·4666 | ... | ... | . |
| Licetus H | +·0383 | +·0381 | + 2 | +·0 |
| Stöfler *f* | +·0641 | +·0633 | + 8 | +·0 |
| Nicolai A | +·2966 | ... | ... | .. |
| Stöfler K | +·0567 | +·0566 | + 1 | +·0 |
| Orontius *d* | −·0829 | −·0829 | 0 | −·0 |
| Walter *a* | +·0093 | +·0090 | + 3 | +·0 |
| ,, (sm. crater)‡ | −·0025 | −·0028 | + 3 | −·0 |
| Hesiodus B | ... | −·2680 | ... | .. |
| Purbach A | −·0295 | −·0296 | + 1 | −·0 |
| Nicollet | ... | −·2003 | ... | .. |
| Thebit A | −·0789 | −·0789 | 0 | −·0 |
| Abenezra *b* | +·1638 | +·1639 | − 1 | +·1 |
| Arzachael A | | | | |

site illuminations tends to eliminate any systematic error depending upon either of these conditions. It is perhaps open to question whether the same amount of labour spent upon measuring and reducing several different plates independently, and taking the means of the resulting places, would not have given a closer approximation to the true values of the coordinates; but the greater part of the work was performed in the endeavour to obtain absolute places from a comparison of two photographs only, without appealing to telescopic measures at all. It was only when this failed that the method finally adopted suggested itself, and I think that the labour spent upon the reductions from that period has yielded an adequate return.

In the following table I give a comparison of the places finally obtained from the two plates with each other, and with those obtained at the telescope. The suffixes as before refer to the Plates II., III. respectively. The column headed "Authority" refers to the telescopic measures, and the initial B. denotes Professor Barnard, F. Dr. Franz, and S. myself.

*Heliometer Measures by Dr. Franz, and Filar Micrometer Measures by by S. A. Saunder.*

| | | Values of $\eta$. | | | | |
|---|---|---|---|---|---|---|
| Plate II. | Plate III. | II.-III. | Mean of II. & III. | Telescopic. | Photographic – Telescopic. | Authority. |
| −·7960 | −·7964 | +·0004 | −·7962 | ... | ... | |
| −·7285 | −·7287 | + 2 | −·7286 | ... | ... | |
| −·7197 | ... | ... | ... | −·7202 | +·0005 | F. |
| −·7182 | −·7182 | 0 | −·7182 | ... | ... | ... |
| −·6774 | −·6773 | − 1 | −·6773 | ... | ... | ... |
| −·6742 | ... | ... | ... | −·6749 | + 7 | F. |
| −·6352 | −·6352 | 0 | −·6352 | ... | ... | ... |
| −·6345 | −·6345 | 0 | −·6345 | ... | ... | ... |
| −·5935 | −·5935 | 0 | −·5935 | ... | ... | ... |
| −·5546 | −·5545 | − 1 | −·5545 | ... | ... | ... |
| ... | −·4556 | ... | ... | −·4555 | − 1 | S. |
| −·4405 | −·4406 | + 1 | −·4405 | ... | ... | ... |
| ... | −·3725 | ... | ... | −·3730 | + 5 | S. |
| −·3677 | −·3673 | − 4 | −·3675 | −·3674 | − 1 | S. |
| −·3550 | −·3548 | − 2 | −·3549 | −·3552 | + 3 | S. |
| −·3903 | −·3903 | 0 | −·3903 | ... | ... | ... |
| −·3025 | −·3024 | − 1 | −·3025 | ... | ... | ... |
| −·2926 | −·2926 | 0 | −·2926 | −·2929 | + 3 | S. |

| | | | | | |
|---|---|---|---|---|---|
| | " | " | " | | |
| Halley | +·0999 | +·0994 | + | 5 | · |
| Hipparchus C | +·1422 | +·1426 | − | 4 | · |
| Euclides | ... | −·4892 | ... | | |
| Hipparchus L | +·1560 | +·1565 | − | 5 | · |
| " G | +·1288 | +·1292 | − | 4 | · |
| " π | +·0873 | +·0871 | + | 2 | + |
| Mösting A | −·0904 | −·0904 | | 0 | − |
| Hipparchus H | +·0526 | +·0528 | − | 2 | + |
| Gambart A | ... | −·3209 | ... | | |
| Triesnecker B | +·0068 | +·0067 | + | 1 | + |
| " | " | " | " | | |
| Cayley | +·2602 | ... | ... | | |
| Murchison A | +·0199 | +·0199 | | 0 | + |
| Hortensius | ... | −·4660 | ... | | |
| Sosigenes *a* | +·3144 | ... | ... | | |
| Bode B | −·0531 | −·0528 | − | 3 | − |
| " A | −·0201 | −·0200 | − | 1 | − |
| Proclus | +·7022 | ... | ... | | · |
| Macrobius *a* | +·6107 | ... | ... | | · |
| Conon | +·0324 | +·0326 | − | 2 | + |
| Bessel | +·2865 | ... | ... | | · |
| Aratus | +·0727 | +·0728 | − | 1 | + |
| Archimedes A | −·0983 | −·0983 | | 0 | − |
| " *c* | −·0221 | −·0223 | + | 2 | − |
| " *b* | −·0268 | −·0276 | + | 8 | − |
| Kirch | −·0754 | −·0755 | + | 1 | − |
| Cassini *b* | | | | | |

| Values of $\eta$. | | | | | | |
|---|---|---|---|---|---|---|
| Plate II. | Plate III. | II.–III. | Mean of II. & III. | Telescopic. | Photographic – Telescopic. | Authority. |
| ... | −·2829 | ... | ... | −·2833 | + 4 | F. |
| −·2604 | −·2605 | + 1 | −·2605 | ... | ... | ... |
| ... | −·2516 | ... | ... | −·2515 | − 1 | S. |
| −·1817 | ... | ... | ... | −·1817 | 0 | S. |
| −·1480 | −·1480 | 0 | −·1480 | −·1479 | − 1 | B. |
| ,, | ,, | ,, | ,, | −·1478 | − 2 | S. |
| −·1390 | −·1394 | + 4 | −·1392 | ... | ... | ... |
| −·1285 | −·1285 | 0 | −·1285 | −·1285 | 0 | S. |
| ... | −·1279 | ... | ... | −·1283 | + 4 | S. |
| −·1190 | −·1192 | + 2 | −·1191 | ... | ... | ... |
| −·0872 | −·0872 | 0 | −·0872 | −·0875 | + 3 | S. |
| −·0843 | −·0841 | − 2 | −·0842 | ... | ... | ... |
| −·0558 | −·0556 | − 2 | −·0557 | −·0556 | − 1 | F. |
| −·0386 | −·0382 | − 4 | −·0384 | ... | ... | ... |
| ... | +·0167 | ... | ... | +·0170 | − 3 | S. |
| +·0205 | +·0204 | + 1 | +·0204 | +·0205 | − 1 | B. |
| ,, | ,, | ,, | ,, | +·0206 | − 2 | S. |
| +·0690 | ... | ... | ... | +·0690 | 0 | S. |
| +·0697 | +·0697 | 0 | +0·697 | ... | ... | ... |
| ... | +·1130 | ... | ... | +·1128 | + 2 | S. |
| +·1353 | ... | ... | ... | +·1349 | + 4 | S. |
| +·1523 | +·1520 | + 3 | +·1521 | +·1525 | − 4 | S. |
| +·1564 | +·1568 | − 4 | +·1566 | +·1569 | − 3 | S. |
| +·2772 | ... | ... | ... | +·2770 | + 2 | F. |
| +·3342 | ... | ... | ... | +·3345 | − 3 | F. |
| +·3697 | +·3693 | + 4 | +·3695 | ... | ... | ... |
| +·3701 | ... | ... | ... | +·3704 | − 3 | S. |
| +·4004 | +·4003 | + 1 | +·4003 | ... | ... | ... |
| +·4699 | +·4699 | 0 | +·4699 | ... | ... | ... |
| +·5238 | +·5237 | + 1 | +·5238 | ... | ... | ... |
| +·5702 | +·5697 | − 5 | +·5699 | ... | ... | ... |
| +·6321 | +·6321 | 0 | +·6321 | ... | ... | ... |
| +·6422 | +·6422 | 0 | +·6422 | ... | ... | ... |
| +·6488 | +·6489 | − 1 | +·6488 | ... | ... | ... |
| +·6601 | +·6603 | − 2 | +·6602 | ... | ... | ... |
| +·6671 | +·6668 | + 3 | +·6670 | ... | ... | ... |
| ... | +·7380 | ... | ... | +·7376 | + | F. |

### § 7. *Discussion of Results obtained.*

It is satisfactory to note that no two positions of the same point are separated by as much as a second of arc, though in two or three cases this limit is approached. Some part of the discordances found may be real, depending, as has been shown by Dr. Franz, upon the elevation above or depression below the surface of the sphere most nearly representing the figure of the Moon. But it must be borne in mind that concordance between the places derived from the two photographs does not prove the accuracy of those places, otherwise the attempt to determine absolute places by securing such concordance would have succeeded. The real test is to be found in the agreement of places derived from the photographs with those obtained at the telescope.

The mean distance between these positions for the six points measured by Dr. Franz is 0″·53, these points being shown on only one plate each. For the nineteen points measured by myself there are twenty-eight photographic measures on the two plates, and the mean of the twenty-eight divergences is 0″·38, whilst for the ten points which have been measured on both plates the mean divergence between the telescopic and the mean photographic places is 0″·32. The mean divergence for the eighteen points measured on Plate II. is 0″·37 ; for the eighteen points measured on Plate III. it is 0″·42.

The greater divergence exhibited by the six points measured by Dr. Franz is, I think, chiefly due to the fact that they are not well defined on the photographs. There is not one of them that I should have selected as a really satisfactory point for accurate measurement on these particular plates, and I am pleased to find that the divergence is no greater. This I think may be taken as a satisfactory indication that the scale and orientation are well determined, so that divergences do not sensibly increase as we recede from the centre. I think also it may be fairly concluded from the whole comparison that the position of a point on any part of the surface may be determined from a single photograph on which it is well defined with an error less than one second of arc.

In estimating the advance thus made towards the accurate determination of selenographic positions it must be remembered that we are not dealing with stellar points; that in the most favourable cases, such as those here considered, we have to estimate the centre of a formation seldom less than 5″ or 6″ in diameter, and frequently more, subject to all the confusion produced by a transition from dazzling brightness to the blackest shade, and that therefore it is not to be expected that the position of a lunar formation should be capable of as accurate determination as that of a fixed star. I may perhaps be pardoned if I again call attention to the fact that the mean

distance between two positions of the same point found by Mädler and Lohrmann respectively, as determined from the eleven points measured as "points of the first order" not less than five times by each, was 5″·2, or almost exactly ten times the average discordance between the six points measured by Dr. Franz and my own determination of their positions, each from one photograph only, under conditions which were certainly not too favourable to the photographs.

The accuracy now attained is, I think, sufficient for such purposes as the preparation of large-scale maps, the computation of the Sun's altitude as required for determining the heights of mountains, and for the great problem to which these are subsidiary, the detection of possible changes on the surface.

But of greater importance than the increase of accuracy in the determination of a few isolated points is the enormous increase in the number of points which can now be accurately measured. With the old methods the computations required for the determination of "points of the first order" were so tedious that rougher methods were devised for determining points of the "second" and "third order," as they were called. These carried with them all the errors of the points of the first order from which they were measured, whilst introducing others due to the methods adopted for the reduction.

Beer and Mädler's map was based on 105 points of the first order, Schmidt's on 157. As a foundation for the outline maps which are being issued by the British Astronomical Association, I have already measured seventy-four points on an area equal to ·014 of the projection of the visible hemisphere (*B.A.A. Memoirs*, vol. x., 5th Report of the Lunar Section). This area is the corner of the S.W. quadrant near the centre of the disc, and includes the whole of *Hipparchus* and portions of the neighbouring formations. It was selected as a suitable region for the commencement of a scheme for remapping the whole surface, and if this is well taken up it is proposed to gradually extend the area. More points might have been measured on either of the plates, but I preferred to limit myself to those which could be measured with a fair approach to accuracy on both, and I have every reason to believe that these seventy-four points are determined with errors very little in excess of those in the list now given. With more photographs it will be possible to measure other points in the same area, as well as to increase the accuracy of those already measured. Some regions will perhaps give an even closer aggregation of measurable points, whilst the large seas will probably not give so many. But the density of distribution on the area already measured corresponds to more than 5,000 on the whole hemisphere. These will again serve as points of reference by which to fix the still more numerous points not at present shown in the photographs, but easily seen in a small telescope, and in which we are most likely to detect evidences of those changes which have been

so strongly suspected by the most trustworthy selenographers, and so ruthlessly rejected by the majority of the writers of astronomical text-books.

### § 8. *Focal Length of the Paris Telescope and Scale of the Photographs.*

In § 13 of my previous paper I gave the values found for the focal length of the photographic object glass of the Paris great Equatorial Coudé from the measures then made. These were vitiated by an erroneous assumption as to the size of the réseau square employed, which was really 5·040 mm., instead of 5·000 mm., as well as by the errors attendant upon limb measures. With the scale values now adopted it appears that a side of the réseau square on Plate II. corresponds to 57″·55, and on Plate III. to 57″·59. The values which I obtain for the focal length of the telescope are 18·064 m. on 1899 February 18, and 18·052 m. on 1895 September 9. The temperatures on these two nights were probably very different, but the difference of focal length is of the opposite sign to that which would be expected from this cause alone.

### § 9. *Conclusion.*

The computations have been almost entirely performed with a "Brunsviga," which is admirably adapted, not only for computing expressions of the form $Ax+By+Cz$, of which a large part of the work has consisted, but also for forming the normal equations in a least square solution, and for the eliminations according to Gauss' method. The computations have been carried to not less than five places throughout; where there appeared to be special danger of cumulative error more figures have been retained. The values of $\xi$, $\eta$ given by the photographic plates have been doubly computed—first by applying the differential corrections to the values computed with the approximate plate constants, and secondly directly from the measured coordinates with the corrected values of the plate constants.

I should hope that the positions now obtained are sufficient both in number and in accuracy to allow of the determination of the constants of a plate by the method proposed by Professor Turner, and described in § 9 of my previous paper, by which a considerable reduction is effected in the amount of computation required. My next step will be to endeavour to reduce a plate in this way. If I am successful progress in the future will be more rapid than it has been in the past.

The plates, as stated in my previous paper, are positive copies on glass, kindly made for me by Mr. Bellamy, of the University Observatory, Oxford, from Paris negatives, for which I am indebted to the generosity of M. Loewy.

The photographic measures were made with an astrographic micrometer of the pattern in use at Greenwich and Oxford, the property of the University Observatory, Oxford, and kindly lent me by Professor Turner, who has not only placed the resources of the Observatory at my disposal, but has supplemented them with a large share of personal advice and assistance, for all of which my most hearty thanks are due.

### § 10. *Comparison of Results with those in Breslau "Mitteilungen," Vol. I.*

Since this paper was written copies have been received in England of the first volume of the *Mitteilungen* of the Breslau Observatory, in which Dr. Franz gives the places of 150 lunar formations as determined by the measurement of five Lick photographs, and it has been with great interest that I have compared his methods and results with my own. In what may be considered the essentials of the methods we agree: we have both made our work independent of direct measures of the limb, and have determined the constants of our plates by comparing the photographic measures of a number of points with the positions of the same points determined by telescopic measures from *Mösting A*; but in the details there are many points of difference.

Professor Franz's telescopic measures have been made with the heliometer, my own with the filar micrometer, the bisection of two formations with the latter instrument being an entirely different operation from the superposition of their images with the former. Dr. Franz has been able to measure eight points near the limb. I have been obliged to measure a greater number nearer the centre, although I have been able to avail myself to a limited extent of his published results, as explained above.

The photographs which Dr. Franz has measured have all been taken near the time of full Moon, so that a great number of the objects measured have appeared only as light spots, no detail being visible. My photographs show but little more than half the disc illuminated, and I have not measured a crater unless a considerable portion of the wall could be made out.

In measuring the photographs Dr. Franz has bisected the craters with a thread moved by a screw, the reading of which, added to that of an accurate scale on which the microscope was carried, gave the measured coordinate. I have measured with a réseau and a graduated cross in the eyepiece, the setting being made either by getting equal readings on opposite arms where they cut the crater walls, or by setting the crater symmetrically in one of the squares formed by the longer (fifth or tenth) division lines.

The reductions have also been performed by quite independent methods.

It would thus seem unlikely that the two sets of places should be affected by the *same* systematic errors.

In order to compare the results it was necessary for me to give relative weights to my own photographic and telescopic measures. I find that the probable error of a coordinate measured on one photographic plate is 0″·09, as determined from the divergences between the two plates. The corresponding probable error for the mean of four telescopic measures was found in § 2 to be 0″·10. But it has already been pointed out that the measure of the discordance between the two plates may give too high an estimate of the value of the absolute results obtained, since errors in the constants give systematic errors in the results, and the method of solution renders it probable that these will be in the same direction in the two plates. I have therefore given to a coordinate obtained from one plate half the weight of the mean of four telescopic measures. I may note in passing that Dr. Franz gives no weight to his photographic measures as compared with those made with the heliometer.

In addition to *Mösting A* and the six points already referred to, there are seventeen points that Dr. Franz and I have both measured. In the following table I compare the positions which result from this combination of my own measures of these points with those found by Dr. Franz :—

| | Values of $\xi$. | | | Values of $\eta$. | | |
|---|---|---|---|---|---|---|
| | J. F. | S. A. S. | F.-S. | J. F. | S. A. S. | F.-S. |
| Nicollet | −·1997 | −·2000 | +·0003 | −·3732 | −·3728 | −·0004 |
| Thebit A | −·0794 | −·0791 | − 3 | −·3677 | −·3674 | − 3 |
| Airy (sm. crater) | +·0746 | +·0745 | + 1 | −·3028 | −·3025 | − 3 |
| Airy A | +·1278 | +·1277 | + 1 | −·2930 | −·2928 | − 2 |
| Lubiniezky B | −·3859 | −·3863 | + 4 | −·2520 | −·2515 | − 5 |
| Ptolemæus A | −·0138 | −·0140 | + 2 | −·1480 | −·1479 | − 1 |
| Hipparchus C | +·1422 | +·1423 | − 1 | −·1288 | −·1285 | − 3 |
| Euclides | −·4880 | −·4888 | + 8 | −·1287 | −·1282 | − 5 |
| Hipparchus G | +·1289 | +·1288 | + 1 | −·0874 | −·0874 | 0 |
| Gambart A | −·3211 | −·3210 | − 1 | +·0167 | +·0169 | − 2 |
| Cayley | +·2599 | +·2603 | − 4 | +·0688 | +·0690 | − 2 |
| Sosigenes *a* | +·3139 | +·3145 | − 6 | +·1351 | +·1350 | + 1 |
| Bode B | −·0530 | −·0529 | − 1 | +·1520 | +·1523 | − 3 |
| „ A | −·0198 | −·0200 | + 2 | +·1562 | +·1568 | − 6 |
| Bessel | +·2855 | +·2859 | − 4 | +·3699 | +·3703 | − 4 |
| Aratus | +·0724 | +·0728 | − 4 | +·4005 | +·4003 | + 2 |
| Archimedes A | −·0984 | −·0983 | − 1 | +·4698 | +·4699 | − 1 |

In no case does the discordance between two positions amount to 1″ of arc (geocentric). The only formation for which this value is approached is *Euclides*, which was not well defined on

Dr. Franz's photographs. This one may conjecture to have been due to the brightness of its surroundings.

The comparison reveals a systematic difference of ·0002 in the ordinates, but is consistent with the supposition that the differences in the abscissæ are accidental.

This difference in the ordinates is slightly increased when the comparison is made between Dr. Franz's positions and my telescopic positions only, whilst it would have practically disappeared from the photographic measures had I adopted the ordinate of the centre derived in § 5 from the photographic measures of the six points measured with the heliometer by Dr. Franz.

The result therefore justifies my rejection of these photographic measures so far as the abscissa of the centre is concerned, but gives reason for suspecting a real systematic difference of about o″·2 in the ordinates between Dr. Franz's positions found with the heliometer and mine found with the filar micrometer.

The mean geocentric distance between the positions of the same point, as found by Dr. Franz and myself, is o″·39, or less than one-thirteenth of the corresponding mean distance between positions found by Lohrmann and Mädler. There was also a systematic difference of a different kind between the ordinates found by these observers about fifteen times as great as that between Dr. Franz and myself, Lohrmann placing his points further from the equator than Mädler.

That small systematic differences should appear is not surprising. Dr. Franz calls attention to their existence between different parts of his own work, and I have already noted the same feature with regard to my work in the *Fifth Report of the Lunar Section of the British Astronomical Association.*

It says much for the general accuracy of the method that both these and the accidental differences should be as small as they are; and it is a great gratification to me to find my own work in such close agreement with that of one who has, I believe, given more attention to selenographic measurements than any other living astronomer, and to whom we owe the best determinations both of the physical libration and of the figure of the Moon.

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*Recent Observations of the Position of Nova Aurigæ with the 40-inch Telescope of the Yerkes Observatory.* By E. E. Barnard.

Shortly after the announcement of Dr. Anderson's discovery of *Nova Aurigæ* in 1892 February Mr. Burnham made a careful set of measures of its position with reference to some thirteen stars near it.

The results of this work are given by him in a paper in

*Monthly Notices* for 1892 April. In the same publication for 1892 December he gives his observations of the brightness of the *Nova* as it slowly faded out. These observations were made with the 36-inch equatorial of the Lick Observatory. From March 13 of that year, when his determinations of magnitude began, until April 26, when proximity to the Sun prevented further work, the star had diminished from the 8th to the 16th magnitude. In Mr. Burnham's opinion it could not have been seen with the 36-inch for more than one week longer even had the star been favourably placed for observation. After March 13 the decrease in light was essentially uniform at the rate of 0·18 magnitude a day.

In August of the same year the star had brightened up again to between the 10th and 11th magnitudes, and had undergone a remarkable physical change, as shown by both visual and spectroscopic observations, indicating that the *Nova* then possessed the characteristics of a planetary nebula.

This star has faded considerably in the past few years, and is now of about the 13th magnitude.

In *Astronomische Nachrichten*, 3143, 3238, and 3279, I have given micrometer measures of the *Nova* with respect to two of Mr. Burnham's comparison stars, E and F of his diagram in *Monthly Notices* for 1892 April. These measures showed that in the two years during which the star was under observation no appreciable change occurred in its position, there being no evidence of parallax or proper motion, implying an enormous distance from the Earth.

My own measures were also in close agreement with those of Mr. Burnham.

The *Nova* has been examined a few times with the 40-inch, and I have in the past winter secured some further measures of its position with the large telescope. These show that no change has occurred in its place in the past eight years.

Mr. Newall has questioned the nebulous condition of the star, though the spectroscope has shown that it has the spectrum of a planetary nebula.

At the second appearance in 1892, when it had brightened up from the 16th, in May, to the 10th or 11th magnitude in August, it was found to have undergone a change both in appearance and in its spectrum. It had become bluish-white in colour, though in the earlier stages of its first appearance it was yellowish, and had seemed to grow redder as it diminished in brightness. It had also the appearance of a nebulous star.

In the present observations with the 40-inch the star was much fainter than at the measures with the 36-inch. On 1900 November 3 a direct estimation made it of the $13\frac{1}{2}$ magnitude, while from a comparison with the stars near it, whose magnitudes had been determined by Mr. Burnham, I found it to be of the 13·0 magnitude on Burnham's scale of magnitudes. On this date a determination of the difference of focus between the *Nova*

and the star F made the focus of the former 0·3 inch further out than for F. It was not as well defined as the stars.

During these observations the position of the *Nova* was again measured with reference to E and F on some five nights. The results are given as follows :—

*Positions of Nova Aurigæ in* 1900.

A and F.

| | | | |
|---|---|---|---|
| Nov. 3 | 1900·842 | 32°46 | 84″96 |
| 5 | ·847 | 32·52 | ... |
| 22 | ·894 | 32·73 | 84·87 |
| 26 | ·905 | 32·64 | 84·93 |
| Dec. 8 | ·937 | 32·75 | 85·09 |
| | 1900·885 | 32·62 | 84·96 |

A and E.

| | | | |
|---|---|---|---|
| Nov. 3 | 1900·842 | 323°28 | 74″49 |
| 5 | ·847 | 323·04 | ... |
| 22 | ·894 | 323·34 | 74·35 |
| 26 | ·905 | 323·16 | 74·63 |
| Dec. 8 | ·937 | 323·22 | 74·59 |
| | 1900·885 | 323·21 | 74·51 |

On November 5 clouds prevented distance measures. November 22 the measures were hurriedly made.

Following are the means of the different seasons' measures of the *Nova* and these two stars. Those of 1892, 1893, and 1894 were made with the 36-inch of the Lick Observatory. Those of 1900 were made with the 40-inch of this observatory.

*Means for each Season of Observation.*

A and E (E = 12ᵐ).

| | | | |
|---|---|---|---|
| 1892·9 | 323°38 | 74″58 | 16 nights. |
| 1893·9 | 323·43 | 74·51 | 14 „ |
| 1894·9 | 323·41 | 74·66 | 3 „ |
| 1900·9 | 323·21 | 74·51 | 5 and 4 „ |
| 1895·6 | 323·377 | 74·543 | Weighting by number of nights |

A and F (F = 10·5ᵐ).

| | | | |
|---|---|---|---|
| 1892·9 | 32°63 | 84″94 | 18 nights. |
| 1893·9 | 32·89 | 84·91 | 8 „ |
| 1894·9 | 32·63 | 84·94 | 3 „ |
| 1900·9 | 32·62 | 84·96 | 5 and 4 „ |
| 1895·6 | 32·675 | 84·927 | Weighting by number of nights. |

If now we compare the means for each year with the means of all the measures of the different years, we shall have the following:

*Yearly Means Compared with the Means of all the Measures.*

| | A and F. | | | A and E. | |
|---|---|---|---|---|---|
| | ° | ″ | | ° | ″ |
| 1892 | +0·045 | −0·009 | 1892 | −0·003 | −0·037 |
| 1893 | −0·145 | +0·038 | 1893 | −0·053 | +0·037 |
| 1894 | +0·045 | −0·013 | 1894 | −0·033 | −0·114 |
| 1900 | +0·055 | −0·036 | 1900 | +0·167 | +0·031 |

These are in satisfactory agreement and show no certain change in the position of the *Nova*. They also show, as has been found in other measures, especially in those of the fifth satellite of *Jupiter*, that the same observer using the 36-inch of the Lick Observatory and the 40-inch of the Yerkes Observatory experiences no personality due to the different instruments, the measures made with one instrument being in perfect harmony with those made with the other.

The measures made by Mr. Burnham and given in *Monthly Notices* for 1892 April are, after correcting an error in the mean for the distance AE from 74·24 to 74″·32:

*Mr. Burnham's Measures of the Nova.*

| | A and E. | | |
|---|---|---|---|
| 1892·14 | 323° 60 | 74″·32 | 3 nights. |
| | A and F. | | |
| 1892·12 | 32°·38 | 85″·05 | 4 nights. |

These give the following differences from my observations:

| A and E. | | A and F. | |
|---|---|---|---|
| −0°·22 | +0″·22 | +0°·29 | −0″·12 |

These are, considering the faintness of the objects and the distances measured, in as close agreement as would be expected from different observers. It is evident that further measures of this object for many years to come would be useless.

In looking up references to *Nova Aurigæ* the following corrections have been noted.

In *Astronomische Nachrichten* 3238, p. 391, F. Renz gives some measures of these objects. His comparison stars were E and F. In his measures the star F is put in the wrong quadrant with reference to the *Nova*, the position angle being given 212. It should be 32°.

In *Monthly Notices* for 1892 April the scale given at the bottom of Mr. Burnham's diagram is wrong. On this scale

the figures read 0″, 40″, 80″. To correspond with the diagram they should be 0″, 80″, 160″. In the same paper, at p. 436, a reference is made to *Astronomische Nachrichten* 3070 : this is a typographical error for 3076.

*Yerkes Observatory, Williams Bay, Wisconsin :*
1901 *July* 29.

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## *Further Observations of Nova Aurigæ in* 1901.

By E. E. Barnard.

*Nova Aurigæ* has been observed on two nights this year, and on each occasion its light was estimated in terms of the comparison stars used by Mr. Burnham in 1892. The comparisons were made with the stars B, E, *e*, G, H and J.

The result from all these made the *Nova* 12·7 magnitude on this scale.

Direct estimates on the two dates made the magnitude 13·0 and 12·9 respectively.

I also made independent estimates of the magnitudes of the comparison stars. They are :

| | B | C | E | *e* | F | G | H | J | M | *m* |
|---|---|---|---|---|---|---|---|---|---|---|
| Oct. 21 | 13·5 | 15·0 | 11·8 | 13·2 | 10·0 | 11·7 | 12·0 | 12·0 | 12·0 | 12·0 |
| 22 | — | 15·0 | 12·1 | 14·0 | 10·0 | 12·0 | 12·3 | 12·4 | 12·5 | — |
| | 13·5 | 15·0 | 11·9 | 13·7 | 10·0 | 11·8 | 12·1 | 12·2 | 12·2 | 12·0 |

Of these stars Mr. Burnham has given the following magnitudes :

B 14·8 C 15·2 E 11·7 *e* 13·2 F 10·4 G 11·5 H 11·8 J 12·7
M 13·2 *m* 13·8.

His estimate of the brightness of B was doubtless influenced by the proximity of the greater brightness of the *Nova* in the spring of 1892.

In my estimates of the magnitudes of M and *m* no note was made for their relative brightness. My recollection is that M was somewhat the brighter of the two.

Under the best conditions the *Nova* has not appeared well-defined when in the best focus. There is a slight haziness about it suggestive of a slightly nebulous star.

1901 *October* 29.

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*On the Variation of T Centauri.* By Alex. W. Roberts, D.Sc.

The variation of the star *T Centauri* (Chandler, 4896), R.A. $13^h\ 36^m\ 2^s$ (1900), Dec.$-33°\ 5'{\cdot}5$, was discovered in 1894 by Colonel Markwick, and independently the same year by Professor Pickering.

The Harvard notification of its discovery is given in the *Astronomische Nachrichten*, No. 3269, p. 72, and that of Colonel Markwick in the *Journal of the British Astronomical Association*, vol. v., p. 247. As far back as 1890, however, its variation was suspected by Kapteyn from an examination of the Cape Photographic Durchmusterung plates. His note on the variable magnitude indicated by the Cape Photographs is contained in *Astronomische Nachrichten*, No. 2987.

The following papers on the variation of *T Centauri* have already appeared in the *Monthly Notices*—

Vol. lvi., p. 35 (Markwick)
„ lvi., p. 347 (Roberts)
„ lvi., p. 500 (Roberts)
„ lviii., p. 513 (Markwick)

in which the nature and period of the star's variation are set forth.

Three years have now elapsed since the last of the four foregoing papers was published, and although observations made during these years have not in any way altered the general conclusions come to then, I think sufficient data have accumulated to enable a very accurate determination of the chief elements of the star's variation to be made.

In arriving at a determination of the period of *T Centauri*, or of any other long-period variable, it should be remembered that the possibility of the period being subject to a secular inequality is not unlikely. Because of this it is as well to include in the investigation only such maxima and minima as have been determined from a full-light curve, or at least from observations so situated on the light curve that they indicate, within a certain margin of error, the date of maximum or minimum brightness.

I have in other papers called attention to the uncertainty which always attaches to isolated meridian observations of magnitude; they are indeed of very little value as an aid to a definitive determination of light period unless the interval which separates the several dates is sufficiently great to compensate for the uncertainty in brightness.

If, of course, a meridian observation is manifestly taken near a maximum or minimum phase, then its value, as an aid to a

determination of the period of the star, is considerably enhanced; but even in this case, the range in brightness is usually so irregular, amounting in the case of *T Centauri* to two magnitudes, that there is always some slight uncertainty with regard to a maximum or minimum date estimated from meridian observations alone.

I propose therefore in the present investigation to base a determination of the period of *T Centauri* upon: (1) Recent systematic observations of magnitude; (2) All available data.

The first portion of the investigation will yield elements which satisfy present observations. If the period of the star is subject to secular inequality, these elements may not satisfy more remote observations.

In the following two series, Tables I. and II., are given the various maxima and minima determined rigorously during the past six years.

All the Lovedale observations were made with a 1-inch telescope, except where the star was passing through its maximum phase. Its brightness then allowed naked-eye estimates to be made.

TABLE I.

*Determinations of Maxima.*

| Rotation No. | Date. | Julian Day. J | Mag. m | Observer. |
|---|---|---|---|---|
| 1 | 1895 June 8 | 2413353 | 5·3 | Markwick |
| 2 | June 10 | 2413355 | 5·8 | Roberts |
| 3 | Sept. 10 | 2413447 | 6·0 | ,, |
| 4 | 1896 March 8 | 2413627 | | Tebbutt |
| 5 | March 10 | 2413629 | 5·4 | Roberts |
| 6 | June 16 | 2413727 | 6·0 | ,, |
| 7 | June 18 | 2413729 | 6·4 | Markwick |
| 8 | Sept. 3 | 2413806 | 5·7 | Roberts |
| 9 | 1897 June 1 | 2414077 | 6·2 | Markwick |
| 10 | 1898 June 3 | 2414444 | 6·6 | ,, |
| 11 | Sept. 1 | 2414534 | 5·9 | Roberts |
| 12 | 1899 Feb. 25 | 2414711 | 5·2 | ,, |
| 13 | June 3 | 2414809 | 6·2 | ,, |
| 14 | Aug. 28 | 2414895 | 5·5 | ,, |
| 15 | 1900 Feb. 25 | 2415076 | 6·0 | ,, |
| 16 | May 24 | 2415164 | 5·6 | ,, |
| 17 | Aug. 25 | 2415257 | 6·1 | ,, |
| 18 | 1901 May 23 | 2415528 | 5·9 | ,, |
| 19 | Aug. 22 | 2415619 | 5·8 | ,, |

| | | |
|---|---|---|
| 4 | 1896 April 26 | 2413676 |
| 5 | April 30 | 2413680 |
| 6 | July 24 | 2413765 |
| 7 | 1898 April 18 | 2414398 |
| 8 | 1899 April 10 | 2414755 |
| 9 | July 13 | 2414849 |
| 10 | 1900 April 12 | 2415122 |
| 11 | July 13 | 2415214 |
| 12 | 1901 April 10 | 2415485 |
| 13 | July 12 | 2415578 |

Let now the following values be consi

$P + \Delta p$ = period of variation ;

$T_M + \Delta t_M$ = epoch of maximum ;

$T_m + \Delta t_m$ = epoch of minimum ;

$m$ = annual amount of secul

E = number of periods, reck

J = Julian day of observatic of Tables I. and II.

Then it is evident that the following eq relation of the various quantities to one an

With regard to Table I. :

$$(T_M + \Delta t_M) + E;(P + \Delta p) + \frac{E}{2}$$

We readily obtain from Tables I. and II. the following approximate values of $T_M$, $T_m$ and P,

$$T_M = 2415075^J,$$
$$T_m = 2415033^J,$$
$$P = 90^d.4.$$

With these assumed values and the values of J contained in column 3, we form equations of condition of the type indicated in (1) and (2).

It is not necessary to burden the paper with the statement of these thirty-two equations, or with the several steps in their solution.

The final result is as follows :

| | d. |
|---|---|
| $\Delta t_M =$ | $+1.1$ |
| $\Delta t_m =$ | $-1.0$ |
| $\Delta p =$ | $+0.07$ |
| $\Delta m =$ | $0.000$ |

This gives as the final elements of *T Centauri* for the year 1901 :

| | |
|---|---|
| Epoch of maximum | $= 2415076.1$ |
| Epoch of minimum | $= 2415032.0$ |
| $M-m$ | $= 44^d.1$ |
| Period | $= 90^d.47$ |

The value of $m$ obtained from the equations indicates that for the six years 1895–1901 the period of *T Centauri* was constant. We must not however infer from this that the period is always constant. This does not follow.

With the above corrected elements we now compute theoretical dates for comparison with the observed dates. This comparison is given in the following tables. Column 2 gives the values of E at the date of observation, column 3 the observed date ; column 4 the computed date, and column 5 the residual (O−C).

TABLE III.

*Maxima Dates.*

| Rotation No. | E. | Julian Day. J | Computed Max. J | O−C. d |
|---|---|---|---|---|
| 1 | −19 | 2413353 | 2413357.2 | −4.2 |
| 2 | 19 | 2413355 | 2413357.2 | −2.2 |
| 3 | 18 | 2413447 | 2413447.6 | −0.6 |
| 4 | 16 | 2413627 | 2413628.6 | −1.6 |
| 5 | 16 | 2413629 | 2413628.6 | +0.4 |
| 6 | 15 | 2413727 | 2413719.1 | +7.9 |

| | | | |
|---|---|---|---|
| 14 | − 2 | 2414095 | 2414895·: |
| 15 | 0 | 2415076 | 2415076· |
| 16 | + 1 | 2415164 | 2415166·( |
| 17 | 2 | 2415257 | 2415257·( |
| 18 | 5 | 2415528 | 2415528·; |
| 19 | + 6 | 2415619 | 2415618·; |

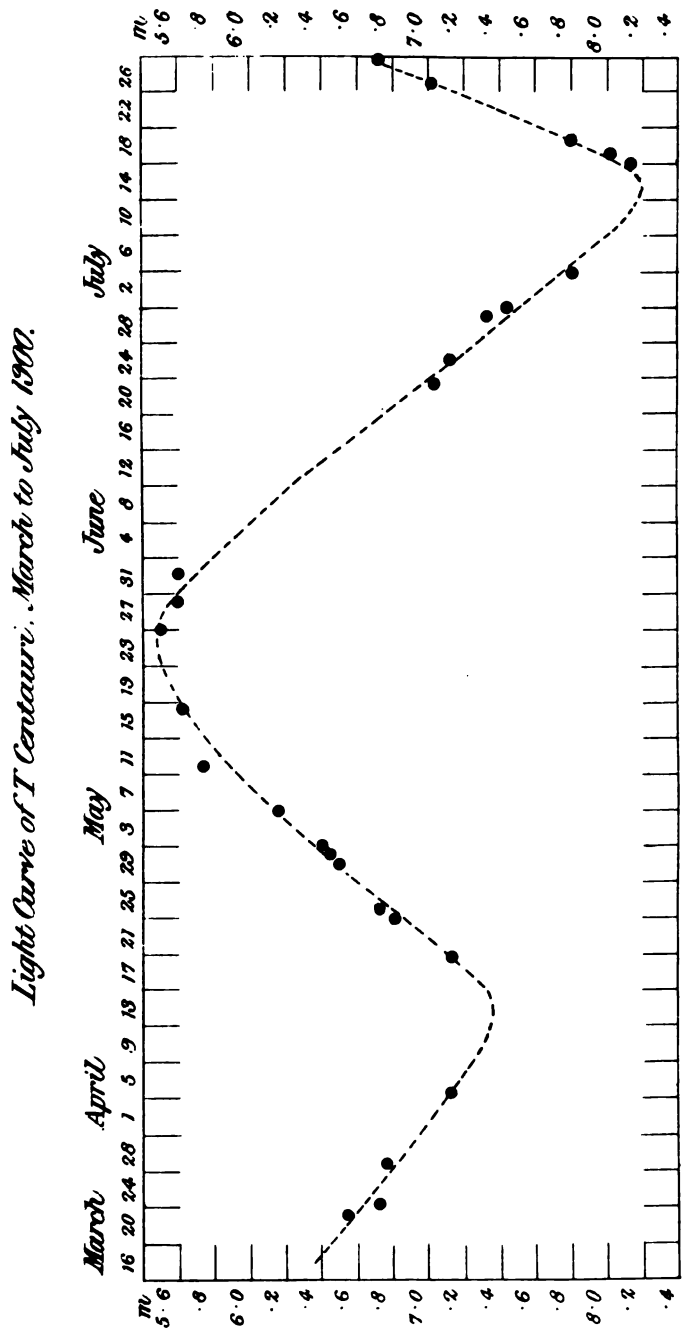
TABLE IV.

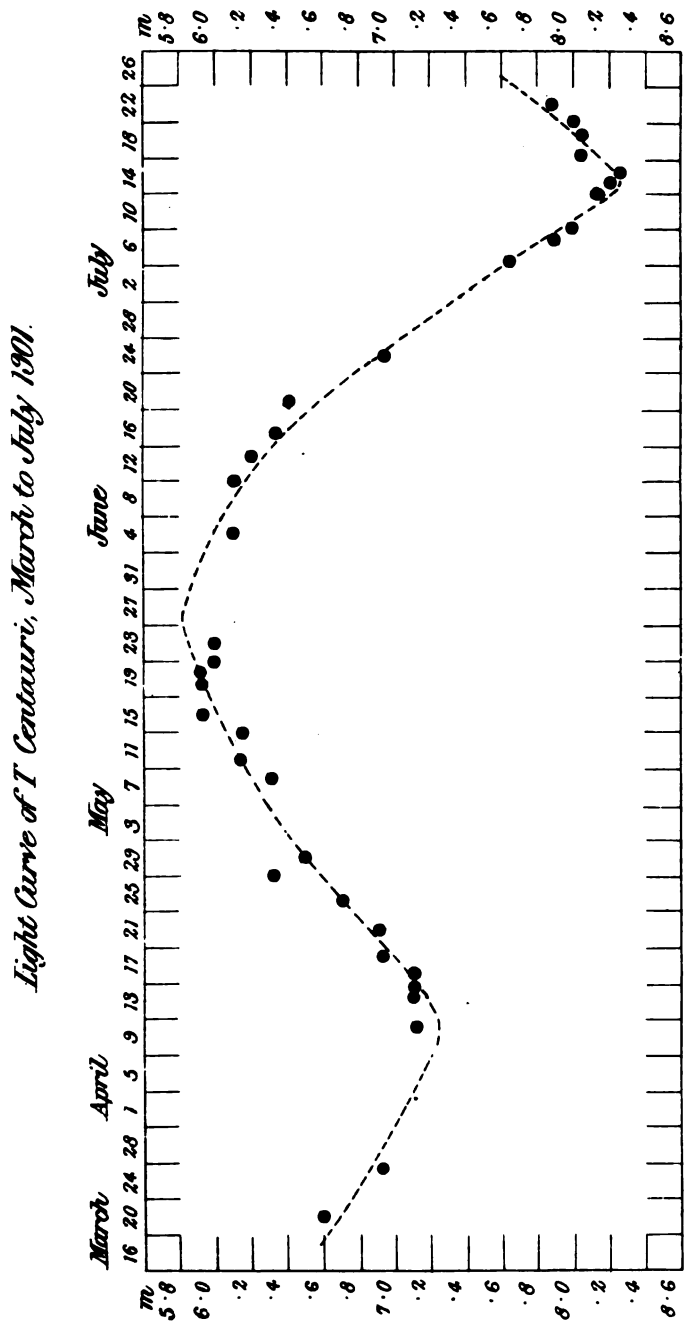
*Minima Dates.*

| Rotation No. | R. | Julian Day. J | Computed Mi J |
|---|---|---|---|
| 1 | −19 | 2413310 | 2413313·1 |
| 2 | 19 | 2413311 | 2413313·1 |
| 3 | 18 | 2413405 | 2413403·5 |
| 4 | 15 | 2413676 | 2413674·9 |
| 5 | 15 | 2413680 | 2413674·9 |
| 6 | 14 | 2413765 | 2413765·4 |
| 7 | 7 | 2414398 | 2413898·7 |
| 8 | 3 | 2414755 | 2413760·6 |
| 9 | − 2 | 2414849 | 2414851·1 |
| 10 | + 1 | 2415122 | 2415122·5 |
| 11 | 2 | 2415214 | 2415212·9 |
| 12 | 5 | 2415485 | 2415484·4 |
| 13 | + 6 | 2415578 | 2415574·8 |

The average residual is :

Maxima dates ... ... ...


Light Curve of T Centauri. March to July 1900.
March
April
May
June
July
m
5·6
6·0
7·0
8·0




*Light Curve of T Centauri, March to July 1901.*

agrees very closely with that determined by Colonel Markwick, forty-three days (*Monthly Notices, R.A.S.*, vol. lviii., p. 514), and indicates that the duration of the ascending period of variation is not markedly unequal to the descending period.

This practical equality between ascending and descending portions of the light curve is a feature of not a few long-period stars.

Colonel Markwick finds a lower limit of $10^{m}\cdot0$ for the variation of *T Centauri*, but I think this is due to his underestimate by more than a whole magnitude of the brightness of two of the comparison stars used by him. The two stars are :

| | | h m s | ° ′ |
|---|---|---|---|
| Z.C. xiii.$^{h}$ | 2039 | 13 34 0 | 33 1·3 (1875) |
| | 2082 | 13 34 36 | 33 7·9 |

The mean brightness of both stars is given in the Zone Catalogue as $8\frac{1}{4}$ magnitude. They have been regularly used at Lovedale as comparison stars for *T Centauri*, and I estimate them as between 8·6 and 8·8 magnitude. They are both distinctly seen in a 1-inch glass.

Colonel Markwick however considers them as 10·0 magnitude, a value which I am convinced is $1\frac{1}{2}$ magnitude too faint.

If allowance be made for this disparity in the reference standards it will be found that the range of magnitude obtained by Markwick confirms that determined at Lovedale.

In one of his papers on this variable Colonel Markwick pointed out that the range of variation was subject to considerable irregularity. This irregularity can be well exemplified by charting down two full cycles, one cycle in 1900 and the other in 1901.

These light curves are given in plates 1 and 2. The apparent similarity between the curves, indicating apparently alternative primary and secondary minima, is fortuitous. There is no regular succession of bright and faint minima, as is the case in some of the better known long period variables.

What has been stated or determined in the preceding part of this paper is deduced directly and solely from recent observations. In the case of *T Centauri* we have fortunately some old observations which I think may reasonably be used either to correct or supplement results obtained from more recent data.

These observations are :—

| | Mag. | |
|---|---|---|
| 1752 June 2 | 7·0 | Lacaille |
| 1846 June 6 | 8·0 | Washington Obsns. |
| 1849 Feb. 13 | 8·9 | ,, |
| March 23 | 8·0 | ,, |
| 1862 April 17 | 6·0 | Yarnall |
| 1863 April 17 | 6·0 | ,, |

| | | Mag. | |
|---|---|---|---|
| 1870 | Jan. 7 | 6·0 | Yarnall. |
| | Jan. 17 | 6·0 | ,, |
| 1872 | May 4 | 7·5 | Washington Obsns. |
| | May 14 | | |
| | May 27 | | |
| 1873 | June 17 | 7·0 | Cordoba Obsns. |
| | June 30 | 7·5 | ,, |
| 1874 | July 2 | 6·8 | ,, |
| | July 3 | 7·5 | ,, |
| | July 4 | 7·3 | ,, |
| | July 11 | 7·0 | ,, |
| 1875 | June 16 | 7·0 | ,, |

As an indication of the uncertainty which must belong to any determination based simply on meridian observations of magnitude, Colonel Markwick regards Lacaille's observation as taken near a maximum of the star. In my judgment the observation was taken near a minimum. In such uncertainty as this the observation must be set aside.

With regard to the early Washington observations we have more definite data to go upon. It is evident that a minimum took place on or about 1849 February 13. Yarnall's observations, also, clearly point to a maximum on or about 1862 April 17.

The Cordoba observations do not indicate a point of reference that we may accept with confidence. I think, however, that 1874 June 15 as the date of a maximum phase is not much in error.

In the *Astronomische Nachrichten*, No. 3269, Professor Pickering gives a valuable series of photographic magnitudes of *T Centauri*.

These indicate a minimum on 1893 July 27.

We have therefore the following four dates to which we may relate recent observations :—

| | | Julian Day. |
|---|---|---|
| 1849 Feb. 13 | Minimum | 2396437 |
| 1862 April 17 | Maximum | 2401248 |
| 1874 June 15 | ,, | 2405690 |
| 1893 July 27 | Minimum | 2412672 |

It is found that a period of $90^{d}\cdot30$ will better satisfy the earlier measures than the period $90^{d}\cdot47$ determined from recent observations. The correspondence with this shorter period is as follows :—

| E. | Observed date. | Computed date. | O−C. d. |
|---|---|---|---|
| −206 | 2396437 | 2396430 | + 7 |
| 153 | 2401248 | 2401260 | −12 |
| 104 | 2405690 | 2405685 | +5 |
| − 26 | 2412672 | 2412684 | −12 |

If the larger value, $90^d{\cdot}47$, be related to the last observation the residual is only $-7^d$. It is evident, therefore, that the period of *T Centauri* is affected by some secular variation, the nature and amount of which we can only discover when a fuller series of observations has been secured.

The mean period of the star will probably be found to be not far from 90·3 days, with a range of from two to three days on either side of this mean period.

I would seek to acknowledge my great indebtedness to Sir David Gill and to Mr. R. T. A. Innes for their ever-ready willingness to make remoteness from a complete astronomical library less of a hindrance in investigations such as the preceding. They were good enough in the present instance to look up for me all the old records of *T Centauri*.

*Lovedale:* 1901 *October* 1.

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*On the Place of the Variable RU Herculis and Neighbouring Stars from Photographic Measures.* By F. A. Bellamy, F.R.Met.Soc.

In No. 3384 of the *Astronomische Nachrichten* Dr. T. D. Anderson refers to a star of the ninth magnitude not given in B.D. He noted it as 9·1 magnitude in 1895 August; it was below the tenth magnitude on October 16, and became invisible later.

As there were several stars in the field of view of similar magnitudes, which rendered it difficult to identify the probable variable star with certainty, it seemed necessary that the position of it should be accurately determined, and this Dr. Hartwig did by measurement from two stars in the Cambridge and Berlin A.G. Catalogues with the heliometer; his results are included in an article on variable stars in *Astronomische Nachrichten*, 3553, and the positions given are

$$1900{\cdot}0 \text{ R.A. } 16^h\ 6^m\ 2^s{\cdot}76 \qquad +25^\circ\ 19'\ 54''{\cdot}7$$

and he adds a note to the effect that his observation was rendered difficult by the low altitude of the star and atmospheric conditions.

This star is in the region apportioned to this observatory for

the Astrographic Chart, and upon examination we find that it has been photographed on three plates.

| | | h m | | | |
|---|---|---|---|---|---|
| 427 | R.A. | 16 4 | +25° | exposed | 1893 June 12 |
| 778 | | 16 8 | +26 | | 1895 May 29 |
| 1406 | | 16 8 | +26 | | 1899 May 26 |

Plate 1406 replaces plate 778, as the latter only showed 76 stars with 2 images and 11 stars with 3 images, the exposures being $6^m$, $3^m$, and $20^s$. Plate 1406 has 188 and 80 stars.

It seems important, as pointed out in a previous paper on *Nova Persei*, that the positions of variables and neighbouring stars should be given accurately. The object of this paper is to give accurate places of the variable star *RU Herculis*, and of all the stars photographed within 20′ of it; therefore all stars probably to the eleventh magnitude. By means of these the positions of other intermediate and fainter stars can readily be determined when required for comparison.

The measures of plate 427 were made by Mr. H. A. Freeborn in 1897 July 23, and of plate 1406 by Miss E. F. Bellamy 1900 September 11–14. The constants $a, b, c, d, e, f$ were determined from a comparison of the computed $\xi'$ and $\eta'$ (1900·0) for stars in the Cambridge and Berlin A.G. Catalogues, with the measures corresponding to the same stars; they are for

| | *a* | *b* | *c* | *d* | *e* | *f* |
|---|---|---|---|---|---|---|
| Plate 427 | +·00762 | +·00164 | −·3719 | −·00190 | +·00762 | −·0918 |
| 1406 | −·00026 | +·00447 | −·2910 | −·00436 | −·00045 | −·1314 |

The application of these constants in the usual way gives the $\xi'$ and $\eta'$ in Table I., but these coordinates need only be given for plate 1406; the right ascensions and declinations (1900·0) were obtained for both plates, and the positions are the means of the two. The eighth and ninth columns contain the differences between the two plates.

The magnitudes in the third column are estimations, to the nearest third or half magnitude, made by myself in November this year.

TABLE I.

| Ref. No. | Camb. A.G.C. | Oxford Mag. | $\xi'$ 1900·0 Plate 1406. | $\eta'$ 1900·0. | Deduced R.A. 1900·0. | Deduced N. Dec. 1900·0. | Difference 1406–427 in R.A. | Difference 1406–427 in Dec. |
|---|---|---|---|---|---|---|---|---|
| | | | | | h m s | ° ′ ″ | s | ″ |
| 1 | 7492 | 9·5 | 1·3834 | 2·9930 | 16 3 43·30 | 25 9 44·6 | +0·13 | −0·7 |
| 2 | | 10·0 | 2 6205 | 1·9904 | 4 10·78 | 4 47·0 | + ·12 | −1·3 |
| 3 | | 9·7 | 2·7987 | 4·5099 | 4 14·32 | 17 23·5 | + ·11 | −2·2 |
| 4 | | 11·0 | 2·8255 | 6·4584 | 4 14·66 | 27 6·8 | ... | ... |
| 5 | | 11·0 | 2 9175 | 8·9776 | 4 16·30 | 39 42·6 | ... | ... |

| Ref. No. | Camb. A.G.C. | Oxford Mag. | ξ' 1900·0 Plate 1406. | η' 1900·0. | Deduced R.A. 1900·0. | Deduced N. Dec. 1900·0. | Difference 1406–427 in R.A. | Difference 1406–427 in Dec. |
|---|---|---|---|---|---|---|---|---|
| | | | | | h m s | ° ′ ″ | s | ″ |
| 6 | | 10·0 | 2·9761 | 5·4301 | 16 4 18·17 | 25 21 59·1 | +0·06 | −0·8 |
| 7 | | 10·5 | 3·5413 | 2·9689 | 4 30·94 | 9 41·8 | + ·16 | −0·2 |
| 8 | | 10·0 | 3·7853 | 8·;807 | 4 35·57 | 38 45·2 | + ·01 | +0·2 |
| 9 | | 9·7 | 3·7778 | 6·5631 | 4 35·71 | 27 40·4 | + ·04 | −0·6 |
| 10 | 7496 | 8·5 | 3·9927 | 3·3620 | 4 40·90 | 11 40·5 | + ·11 | −0·1 |
| 11 | | 9·7 | 4·7037 | 6·5747 | 4 56·36 | 27 45·4 | + ·01 | −0·1 |
| 12 | | 10·3 | 4·7900 | 6·8087 | 4 58·11 | 28 56·0 | ·00 | −0·7 |
| 13 | | 10·7 | 6·9414 | 4·3294 | 5 45·93 | 16 35·8 | + ·15 | −1·3 |
| 14 | | 10·0 | 7·3974 | 3·1658 | 5 56·15 | 10 47·0 | + ·08 | −0·5 |
| 15 | | 11·0 | 7·5099 | 6·2204 | 5 58·41 | 26 3·1 | ... | ... |
| 16 | Variable | | 7·7077 | 4·9903 | 6 2·89 | 19 54·3 | ... | ... |
| 17 | | 10·3 | 7·8055 | 3·3878 | 6 5·15 | 11 53·8 | + ·06 | 0·0 |
| 18 | | 11·0 | 8·1264 | 2·4336 | 6 12·24 | 7 8·3 | + ·20 | −0·9 |
| 19 | | 11·0 | 8·5363 | 5·6330 | 6 21·18 | 23 7·9 | ... | ... |
| 20 | | 9·5 | 8·6046 | 7·2410 | 6 22·58 | 31 10·9 | − ·01 | −1·2 |
| 21 | | 10·0 | 8·7604 | 6·4043 | 6 26·09 | 26 59·6 | ·00 | −0·2 |
| 22 | | 10·7 | 8·8989 | 2·2604 | 6 29·35 | 6 16·6 | + ·15 | +0·3 |
| 23 | | 9·5 | 9·2947 | 7·5711 | 6 37·88 | 32 50·8 | − ·04 | −1·6 |
| 24 | | 11·5 | 9·6254 | 5·2190 | 6 45·31 | 21 4·7 | ... | ... |
| 25 | | 11·5 | 9·8601 | 1·9414 | 6 50·66 | 4 41·7 | ... | ... |
| 26 | | 10·0 | 10·2265 | 6·6907 | 6 58·54 | 28 26·5 | + ·02 | −0·3 |
| 27 | | 11·3 | 10·3339 | 8·3776 | 7 0·86 | 36 52·6 | ... | ... |
| 28 | | 9·5 | 10·7712 | 6·9873 | 7 10·62 | 29 56·1 | − ·02 | −0·8 |
| 29 | 7525 | 8·7 | 10·8004 | 3·7127 | 7 11·38 | 13 33·9 | − ·05 | +0·4 |
| 30 | 7528 | 8·5 | 10·9892 | 9·1522 | 7 15·38 | 40 46·2 | − ·04 | −1·9 |
| 31 | 7533 | 8·7 | 12·1575 | 6·9210 | 16 7 41·32 | 25 29 36·3 | ·00 | 0·0 |

Nos. 4, 5, 15, 19, 24, 25, 27 are not visible on plate 427. Though *RU Herculis* is visible on plates 427 and 778, the images are so faint that satisfactory measures cannot be made; when the scale is placed over them they become invisible.

With regard to the differences (especially in R.A.) it should be mentioned that the constants for these two plates (427 and 1406) were derived from stars in the Catalogue of the Ast. Gesellschaft, observed at Cambridge and Berlin. For plate 1406 all the stars are from the Cambridge, whilst for plate 427 five of

the twenty-five stars used are from the Berlin B. Catalogue, all these being in the southern half of the plate. The question arises whether there is any systematic difference between the R.A.'s of Cambridge and Berlin B. Catalogues.

In the introduction to the Greenwich 1890·0 Catalogue, p. 47, comparisons are given Greenwich—Cambridge and Greenwich—Berlin B., and the systematic differences in R.A. are $-0^s{\cdot}04$ (198 stars) and $-0^s{\cdot}03$ (282 stars), whence C—B is $+0^s{\cdot}01$. But this comparison depends on the brighter stars only, and for our present purpose is illusory; for, the majority of stars in Cambridge and Berlin B. Catalogues are of the 8th to the 9th magnitude, and even fainter, and the Cambridge observations are affected by a very pronounced magnitude equation, as pointed out by Mr. A. R. Hinks (*Monthly Notices*, lvii., p. 473), using 671 stars, and by Professor Turner (*Monthly Notices*, lx., p. 3), using 5,384 stars. In fact, while the R.A.'s of the mean bright star (probably about the $5\frac{1}{2}$ or 6th magnitude) of the Cambridge and Berlin are the same, those of the mean 8th and 9th magnitude star differ by $0^s{\cdot}07$ at least.

If, then, the places from Cambridge and Berlin are taken just as they stand, the lower and southern half of the plate, depending chiefly on Berlin stars, will be displaced in R.A. with reference to the northern half of the plate; and this will alter the orientation (constant $b$) deduced from the $x$ coordinates. Assuming the above difference of $0^s{\cdot}07$, the effect is to increase $b$ by $+{\cdot}00025$, and there is a consequent correction of $-{\cdot}0053$ to $c$. A systematic difference has been noticed in declination by Mr. Hinks, the amount being $0''{\cdot}5$, which will similarly alter the scale value (constant $e$) deduced from the $y$ coordinate.

In the particular case of plate 427 these quantities are probably excessive, for there are 5 Berlin stars in the lower half, but the total number is 8. Nevertheless they are quite inadequate to account for the systematic difference in R.A. as appears from the subjoined Table II., in which the differences in Table I. are compared with those due to the above alterations in $b$ and $c$.

The main cause of the discordance between the two plates must accordingly be sought for elsewhere—probably in the accidental errors of the reference stars (including proper motions from the dates of meridian observations to 1900·0, and for the six years between the two plates)—and though these will ultimately be fully discussed, for the present it will serve the main purpose of this paper to give the mean of the results as they stand, as has been done in Table I.

TABLE II.

*Plate* 1406–427.

| Ref. No. | Difference as in Table I. | Correction for Magnitude Equation. | Difference Corrected. |
|---|---|---|---|
| | s | s | s |
| 1 | +0·13 | −0·03 | +0·10 |
| 2 | + ·12 | − ·03 | + ·09 |

| Ref. No. | Difference as in Table I. s | Correction for Magnitude Equation. s | Difference Corrected. s |
|---|---|---|---|
| 3 | +0·11 | −0·02 | +0·09 |
| 6 | + ·06 | − ·01 | + ·05 |
| 7 | + ·16 | − ·03 | + ·13 |
| 8 | + ·01 | + ·01 | + ·02 |
| 9 | + ·04 | − ·01 | + ·03 |
| 10 | + ·11 | − ·03 | + ·08 |
| 11 | + ·01 | − ·01 | ·00 |
| 12 | ·00 | − ·01 | − ·01 |
| 13 | + ·15 | − ·02 | + ·13 |
| 14 | + ·08 | − ·03 | + ·05 |
| 17 | + ·06 | − ·03 | + ·03 |
| 18 | + ·20 | − ·03 | + ·17 |
| 20 | − ·01 | ·00 | − ·01 |
| 21 | ·00 | − ·01 | − ·01 |
| 22 | + ·15 | − ·03 | + ·12 |
| 23 | − ·04 | ·00 | − ·04 |
| 26 | + ·02 | ·00 | + ·02 |
| 28 | − ·02 | ·00 | − ·02 |
| 29 | − ·05 | − ·02 | − ·07 |
| 30 | − ·04 | + ·01 | − ·03 |
| 31 | ·00 | ·00 | ·00 |

The plates afford some information as to the magnitude of the variable. On plate 427 ($16^h\ 4^m + 25°$ 1893 June 12) it is at the limit of visibility; in fact, it had been omitted in the original measures of the plate, though stars certainly as faint as 10·5 mag. had been measured, and was only detected when examining it for this paper by first computing its coordinates, and so knowing exactly where to look for it.

The star is visible on plate 778 ($16^h\ 8^m + 26°$ 1895 May 29), but again was only found by previously ascertaining its exact position. The plate had been rejected as having an insufficient number of stars; there were only 11 stars shown by the 20$^s$ exposure, whereas Argelander gives 57 in the same region. It can be inferred that quite 1·5 magnitudes were lost on this plate, and so the magnitude of *RU Herculis* would be about 9·5. It was in 1895 August that Dr. Anderson first noticed that the star was missing in the B.D., and he then estimated it to be 9·1.

When the third plate (1406) was taken, 1899 May 26, the star was very near its maximum, and was undoubtedly as bright or brighter than Camb. 7533 (B.D. + 25°, 3046), magnitude 9·0.

If the star is red in appearance this will be equivalent to increasing the mags. given from the plates by at least several tenths

... by ARTHUR A. Hamba
Radcliffe Observ

This paper contains the results
brightness and colour of the new sta
Radcliffe Observatory since the date
Society, and is in continuation of the
already communicated to the Societ
*Monthly Notices* for March, April, Ma

The periodical fluctuations in the
which had been observed up to the end
appeared to die out about the middle
observed maximum ($4^m \cdot 57$) was on Jun
of magnitude was $5^m \cdot 80$ on June 17,
observations show a gradual diminution
of about $0^m \cdot 01$ per diem, the magnitu
7·1. If the magnitudes be plotted as or
abscissæ, a straight line drawn throu
$0^m \cdot 2$ of all observations, and the discre
periodicity. Small changes of brightne
suspected by the observers in the course

During the months of June and Jul
under unfavourable conditions at a sn
northern horizon. In July the image of t
noted as being "dull," and "larger" th
since then it has generally appeared shar

On August 22 the image of the *Nova*
to test whether any trace could be
aureole which MM. Antoniadi and Fla
rounding the photographic image. No
aureole could be discovered (see Obs
date).

A marked change has also taken pla
star. The ...

on one or two occasions, an indication of blue. Since July 3 the star *Arg. Z.*+43°, 730 (No. 58 in Table I.) has appeared considerably redder than the *Nova*.

The stars *Arg. Z.* +44°, 734 and *Arg. Z.* +43°, 730 (Nos. 54 and 58 in Table I.) have been frequently used as comparison stars. If the magnitudes given in the Harvard Photometry, Harvard Photometric Revis., and Harvard Photometric D.M., be accepted, it is found that the magnitude of the *Nova* resulting from a comparison with these stars differs systematically from that deduced by comparison with the other stars. Comparing the magnitudes of these two stars with a number of others the resulting magnitudes on the Harvard scale were found to be 6·23 and 6·57 respectively. The magnitudes given for No. 54 in the H.P., H.P. Revis., and H.P. D.M. are 6·04, 6·32, and 6·45. The magnitude given for No. 58 in the H.P. D.M. is 6·91. It will be seen that the Radcliffe estimation of No. 54 on the Harvard scale agrees more closely with the mean of the three photometric results (6·27) than with the first of them, the magnitude hitherto adopted.

These revised magnitudes have been used in Table I. and throughout the comparisons given in this paper.

The following instruments were employed as indicated in the fourth column of Table II. :—

| | *Instruments Used.* | |
|---|---|---|
| Barclay | 10-inch equatorial | Power 90 |
| | 2·7-inch finder | „ 13 |
| Heliometer | 7·5-inch | „ 45 |
| | 1·8-inch finder | „ 19 |
| Ramsden | 2·2-inch | „ 40 |
| Naked eye. | | |

TABLE I.

*List of Stars used for Comparison with Nova Persei.*

| Ref. No. | Name of Star. | Harvard Photom. Mag. | Ref. No. | Name of Star. | Harvard Photom. Mag. |
|---|---|---|---|---|---|
| 50 | *l* Persei | 4·84 | 61 | Arg. Z. + 41°, 631 | 6·00† |
| 51 | 31 Persei | 4·99 | 62 | Arg. Z. + 41, 638 | 6·16† |
| 52 | 30 Persei | 5·37 | 63 | Arg. Z. + 42, 736 | 7·00§ |
| 53 | 36 Persei | 5·40 | 64 | Arg. Z. + 43, 720 | 7·25§ |
| 54 | Arg. Z. + 44°, 734 | 6·23* | 65 | Arg. Z. + 43, 732 | 7·25† |
| 55 | Arg. Z. + 44, 648 | 6·47‡ | 66 | Arg. Z. + 47, 847 | 5·52† |
| 56 | Arg. Z. + 43, 818 | 5·97 | 67 | Arg. Z. + 44, 714 | 7·37† |
| 58 | Arg. Z. + 43, 730 | 6·57* | 68 | Arg. Z. + 47, 844 | 6·04† |
| 59 | Arg. Z. + 42, 795 | 6·30† | 69 | Arg. Z. + 47, 846 | 6·77† |
| 60 | Arg. Z. + 44, 656 | 7·60§ | 70 | Arg Z. + 44, 732 | 7·32† |

* Radcliffe estimations on Harvard scale. † Harvard Photom. D.M.
‡ Harvard Photom. Revision. § Adopted provisionally.

| | | | | | | |
|---|---|---|---|---|---|---|
| July | 1 | 11 | 5 | R. | 7·5 | 52 |
| | 3 | 11 | 0 | R. | 7·5 | 52, 54 |
| | 8 | 11 | 30 | R. | 7·5 | 52 |
| | 9 | 11 | 45 | R. | 1·8 | 52 56, 54, 58 |
| | | 11 | 45 | R. | 7·5 | 52, 54, 58 |
| | 15 | 10 | 30 | R. | 1·8 | 54, 52, 56, 58 |
| | | 10 | 30 | R. | 7·5 | 54, 52, 58 |
| | | 11 | 40 | A. A. R. | 7·5 | 58, 54 |
| | | 11 | 40 | A. A. R. | 1·8 | 58, 54 |
| | 16 | 10 | 15 | R. | 1·8 | 52, 56, 54 |
| | 17 | 11 | 0 | R. | 1 8 | 52, 56, 54. 58 |
| | 18 | 11 | 0 | R. | 1 8 | 56, 52, 54 |
| | | 11 | 20 | C. | 1·8 | 56, 52, 54. 58 |
| | 19 | 10 | 30 | R. | 1·8 | 52, 56, 54 |
| | | 11 | 30 | R. | 2·7 | 52, 56, 54 |
| | 20 | 10 | 0 | R. | 1 8 | 52, 54, 56 |
| | 22 | 10 | 30 | R. | 1·8 | 56, 52, 54 |
| | 23 | 10 | 30 | R. | 1·8 | 52, 54 |

| 1901. | G.M.T. h | m | Observer. | Aperture of Telescope. inch | Reference Stars. | Mean Mag. | Adopted Mag. for the night. |
|---|---|---|---|---|---|---|---|
| Aug. 17 | 10 | 0 | C. | 2·7 | 56, 55, 54, 67 | 6·51 | 6·51 |
| 20 | 10 | 50 | R. | Naked eye | 54, 59 | 6·46 | 6·46 |
| 22 | 9 | 30 | W. | 2·7 | 54 | 6·13 | 6·22 |
| | 9 | 30 | W. | 10·0 | 54, 53 | 6·02 | |
| | 10 | 45 | R. | Naked eye | 54, 59 | 6·46 | |
| 24 | 10 | 20 | R. | 10·0 | 56, 54 | 6·30 | 6·30 |
| 27 | 11 | 53 | R. | 2·7 | 56, 54, 58 | 6·42 | 6·42 |
| 28 | 8 | 45 | R. | 1·8 | 58, 54 | 6·25 | 6·25 |
| Sept. 3 | 7 | 45 | R. | 7·5 | 54, 56, 70–54, 58 | 6·65 | 6·54 |
| | 9 | 0 | R. | Naked eye | 54, 59 | < 6·30 | |
| | 10 | 45 | R. | 2·7 | 56, 58, 54 | 6·42 | |
| 4 | 7 | 43 | R. | 7·5 | 54, 70 | 6·77 | 6·67 |
| | 7 | 43 | R. | 1·8 | 55, 70, 54, 58 | 6·77 | |
| | 8 | 45 | R. | 1·8 | 56, 54, 70, 58 | 6·57 | |
| | 9 | 30 | R. | Naked eye | 54, 59 | 6·57 | |
| 5 | 9 | 7 | W. | 2·7 | 58, 62, 61, 55, 54, 68, 69 | 6·46 | 6·45 |
| | 9 | 7 | W. | 10·0 | 58, 62, 61, 55, 54, 68, 69 | 6·44 | |
| | 10 | 45 | R. | Naked eye | 54 59 | < 6·30 | |
| 7 | 9 | 25 | R. | 2·7 | 65, 54, 58 | 6·58 | 6·58 |
| 9 | 9 | 40 | W. | 10·0 | 58, 64, 65 | 6·77 | 6·65 |
| | 9 | 40 | W. | 2·7 | 58, 62, 61, 64, 55, 69, 68, 66 | 6·72 | |
| | 10 | 15 | R. | Naked eye | 54, 59 | 6·62 | |
| | 11 | 5 | W. | 2·2 | 58, 54, 65 | 6·42 | |
| 10 | 9 | 35 | R. | 2·7 | 56, 54, 58, 65, 64 | 6·72 | 6·72 |
| 11 | 7 | 40 | R. | 7·5 | 70, 54, 56 | 6·74 | 6·54 |
| | 9 | 40 | W. | 2·7 | 58, 54, 62, 63, 56, 69 | 6·52 | |
| | 9 | 40 | W. | 10·0 | 58, 54, 62, 63 | 6·43 | |
| 14 | 8 | 20 | W. | 2·7 | 54, 58 | 6·80 | 6·65 |
| | 8 | 30 | R. | 7·5 | 54, 70, 56 | 6·74 | |
| | 9 | 30 | R. | 1·8 | 54, 56, 58, 65 | 6·46 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 26 | 8 | 30 | C. | 2·7 | 54, 05, 50, 50 |
| | | 8 | 53 | W. | 2·7 | 58, 65, 54, 62, 63, ! |
| | 28 | 9 | 0 | C. | 2·7 | 65, 54, 58, 64, 56, ! |
| Oct. | 4 | 9 | 15 | R. | 2·7 | 58, 54, 70, 67, 65, ( |
| | 5 | 9 | 8 | C. | 2·7 | 65, 54, 64 |
| | 9 | 7 | 45 | R. | 2·7 | 56, 54, 70, 67, 58, ( |
| | 18 | 6 | 50 | R. | 2·7 | 65, 64, 58, 54, 70, |
| | 19 | 8 | 15 | C. | 2·7 | 54, 65, 58, 67, 56 |
| | 21 | 7 | 15 | R. | 10·0 | 58, 54, 70, 56 |
| | 22 | 8 | 30 | C. | 2·7 | 65, 54, 58, 67 |
| | 24 | 8 | 38 | C. | 2·7 | 65, 64, 54, 67, 70, |
| | 25 | 6 | 45 | R. | 2·7 | 65, 64, 70, 67 |
| | | 6 | 45 | R. | 10·0 | 65, 64, 70 |
| | | 9 | 0 | W. | 1·8 | 58, 54 |
| | | 9 | 30 | R. | 1·8 | 65, 64, 67, 70, 58 |
| | 30 | 11 | 0 | R. | 2·7 | 65, 64, 58, 67, 70 |
| | 31 | 8 | 38 | C. | 2·7 | 65, 64, 58, 67, 70 |
| Nov. | 1 | 7 | 0 | R. | 2·7 | 65, 64, 58 |

1901.
July 15. No. 58 is brighter than No. 54 in the 7·5-inch, but the two stars are equal in the 1·8-inch. In both telescopes the Nova is brighter than No. 54. (A.A.R.)
18. Comparison with No. 58 difficult owing to close proximity of other stars. Sky hazy. (C.)
19. Image of Nova in the 10-inch is duller than that of No. 58. Sky hazy in places.
23. Sky nearly overcast; observed in breaks.
24. Difficult observations; cloud occasionally passing.

Aug. 10. Sky very clear and definition good.
15. Haze and thin cloud prevalent. Definition not satisfactory.
17. Sky very clear in Perseus. Definition good.
20. Nova just visible to the naked eye, fainter than Nos. 54 and 59. Sky brilliantly clear.
22. To test whether Flammarion's and Antoniadi's photographic aureole could be detected visually, examined Nova with Barclay Equatorial. No difference of image as compared with other stars could be seen with "finder" or 10-inch telescope, using powers 90 or 250. With 250 all images were diffused to-night. (W.) Nova visible to the naked eye by glimpses only. (R.)
24. In the 10-inch No. 54 is distinctly brighter than Nova, but in the 2·7-inch "finder" it is fainter. Sky foggy.
27. Sky clear, but moonlight strong.

Sept. 3. With the 7·5-inch images sharp and good; objects low, observed in twilight. At times the image of the Nova in the 2·7-inch seemed larger than that of No. 54, but its light was duller. With the naked eye Nos. 54 and 59 were seen with but little difficulty, but the Nova was not visible.
4. Observations difficult with the 1·8-inch. The brightness of the Nova seemed to fluctuate in short intervals to the extent of about 0·2 magnitude. With the naked eye the following sequence of magnitude was recorded:—Nos. 50; 53 and 52 nearly equal; 54 and 59 nearly equal; Nova, by glimpses, but suspected only.
5. To the naked eye Nos. 54 and 59 just visible. Nova invisible. (R.)
7. Images varying; clouds passing. Observations difficult.
9. Sky very clear. (W.) No. 54 is easily visible to the naked eye, brighter than No. 59, which is also picked up with but little difficulty. Both stars are distinctly brighter than Nova, which shows up in glimpses only. (R.)
11. Sky hazy. (R.) Thin cloudlets passing at times and occasional large tracts of cloud. Very good images generally. (W.)
14 A hurried comparison. (W.)
18. Image of the Nova sharp and stellar with the 7·5-inch. Some haze passing during observations with the 1·8-inch.
21. Clouds passing. Object-glasses of 10-inch and 2·7-inch "finder" became quickly covered with moisture. Very damp atmosphere.
25. In the 2·7-inch Nos. 54 and 58 are equal in magnitude. In the 10-inch No. 67 is double, but in the 2·7-inch single.

Oct. 5. Hurried estimations owing to prevalence of cloud.
21. Through passing cloud and mist; observations difficult.
22. Haze and thick low fog prevalent.
25. With the 2·7-inch No. 65 is slightly fainter than No. 64; and Nova is considerably fainter than No. 58. With the 10-inch, power 90, No. 65 is fainter than No. 64. Sky hazy in places and moonlight strong. With the 1·8-inch No. 65 is slightly brighter than No. 64. Sky clearer than at $6^h\ 45^m$ G.M.T.; but some haze still prevalent, with moonlight. (R.)

19. In both 7·5-inch and 10-inch Nova orange a
22. In the 7·5-inch Nova orange-red; No. 58 re
24. In the 7·5-inch Nova less red than No 58.

Aug. 8. In the 10-inch Nova pale yellow, much less
10. In the 10-inch Nova much less coloured tha
orange. At times suspected a reddish fri
17. In the 10-inch Nova is pale yellow; in str
which is deep orange.
24. Nova orange, not so deep as No. 58. Sky f
deep orange.
27. With the 10-inch, power 90: Nova white,
and No. 58 orange. Marked contrast i
180 and 200. Nova nearly colourless, a
Definition not good with the latter power
28. In the 7·5-inch the Nova is colourless and N

Sept. 3. No colour to Nova in the 7·5-inch, except
merest tinge of red was suspected; No.
rich orange-red.
4. In the 7·5-inch No. 58 orange-red, Nova c
inch Nos. 70 and 58 both orange-red.
5. In the 10-inch No. 62 is yellow-red, No.
No. 55 markedly red-yellow. (W.)
7. No. 58 orange-red in the 2·7-inch.
9. No. 58 is red in the 2·7-inch and No. 55 is
the 10-inch with power 90 no marked c
power 100 Nova is reddish; also reddish
not so marked. No. 58 is strongly red.
10. In the 10-inch No. 58 is orange-red and No
11. No colour to Nova in 10-inch or 2·7-inch.
14. Nova colourless in the 7·5-inch and No.
In the 10-inch, power 90, the image
10h G.M.T., a bluish-white disc with a narr
18. No. 58 orange-red in the 7·5-inch.
25. In the 10-inch Nova is bluish-white with
No. 58 is red-orange. No. 67 is double;
the fainter orange.
26. With the 10-inch and power 90 could n
fringe to Nova. (C.) No. 58 yellow in t
inch and power 90 Nova is very light ye

1901.
Oct. 24. Nova white and No. 58 deep orange in the 10-inch.
25. No. 64 is light orange and No. 70 orange-red in the 10-inch, power 90. (R.)
31. In the 10-inch, power 90, Nova is white and is ½rd mag. fainter than No. 58, which is deep orange.

The observers were: Dr. Rambaut, indicated by A.A.R.
Mr. Wickham, „ W.
Mr. Robinson, „ R.
Mr. McClellan, „ C.

*Radcliffe Observatory, Oxford:*
1901 *November* 7.

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*Additional Note on the Green Flash.* By W. H. Pickering.

(*Communicated by the Secretaries.*)

During a recent sea trip I made some further observations upon the green flash at sunset. I was some five or six miles off the Massachusetts coast, and my assistant, Mr. E. R. Cram, and I were watching the Sun set over the land, which was very low at this place. The horizon was fairly clear, and just as the Sun was on the point of disappearing the last ray turned to both of us a bright green. The effect was not so marked, however, as in the sunset I had previously witnessed off the Cuban coast. The next morning Mr. Cram saw the Sun rise out of the ocean, but no unusual colour was observed.

The effect is so marked at sunset that it is singular that it should not have been more generally noticed heretofore. The explanation it seems to me, however, is simple. The effect, I presume, is subjective, and merely a case of complementary colours, like the well-known experiment of gazing fixedly at a red wafer on a white background, then looking away, and seeing a green one in its place. The fact that my assistant could not see it at sunrise, although entirely prepared to do so, confirms this view.

*Harvard Observatory:*
1901 *October* 8.

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|---|---|---|---|---|---|
| 4 | 214 66 | 1·36 | +1·36 | −0·98 | |
| 5 | 226·84 | 1·37 | −0·06 | −2·30 | : |
| 6 | 239·02 | 1·38 | −1·38 | −3·53 | : |
| 7 | 251·20 | 1·39 | −2·55 | −4·61 | ! |
| 8 | 263·39 | 1·40 | −3·53 | −5·50 | ( |
| 9 | 275·58 | 1·41 | −4·29 | −6·14 | ) |
| 10 | 287·77 | 1·42 | −4·84 | −6·50 | ( |
| 11 | 299 96 | 1·43 | −5·18 | −6·54 | 8 |
| 12 | 312·14 | 1·44 | −5·33 | −6·24 | 8 |
| 13 | 324·32 | 1·45 | −5·31 | −5·61 | 7 |
| 14 | 336·50 | 1·46 | −5·11 | −4·66 | 6 |
| 15 | 348·67 | 1·47 | −4·74 | −3·44 | 5 |
| 16 | 0·83 | 1·48 | −4·19 | −2·01 | 4 |
| 17 | 12·99 | 1·48 | −3·43 | −0·43 | 3 |
| 18 | 25·13 | 1·49 | −2·47 | +1·19 | 2 |
| 19 | 37·27 | 1·50 | −1·30 | +2·76 | 3 |
| 20 | 49·41 | 1·51 | +0·04 | +4·17 | 4 |
| 21 | 61·54 | 1·52 | +1·46 | +5·31 | 5 |
| 22 | 73·66 | 1·52 | +2·87 | +6·09 | 6 |
| 23 | 85·79 | 1·53 | +4·15 | +6·48 | 7 |
| 24 | 97·91 | 1·53 | +5·17 | +6·47 | 8 |
| 25 | 110·04 | 1·53 | +5·82 | +6·07 | 8 |
| 26 | 122·18 | 1·53 | +6·06 | +5·34 | 8 |
| 27 | 134·31 | 1·53 | +5·88 | +4·35 | 7 |
| 28 | 146·46 | 1·53 | +5·28 | +3·17 | 6 |
| 29 | 158·61 | 1·53 | +4·34 | +1·87 | 4 |

| Greenwich Midnight. | Selenographical Colong. | Lat. of the Sun. | Geocentric Libration Sel. Long. of the Earth. | Lat. | Combined Amount. | Direction. | C. |
|---|---|---|---|---|---|---|---|
| 1902. | ° | ° | ° | ° | ° | ° | ° |
| Feb. 5 | 243·82 | +1·50 | −4·14 | −6·06 | 7·34 | 145·7 | 353·94 |
| 6 | 256·01 | 1·49 | −4·68 | −6·45 | 7·97 | 144·0 | 348·82 |
| 7 | 268·20 | 1·49 | −4·94 | −6·53 | 8·19 | 142·9 | 344·22 |
| 8 | 280·40 | 1·48 | −4·93 | −6·26 | 7·97 | 141·8 | 340·38 |
| 9 | 292·60 | 1·48 | −4·69 | −5·65 | 7·34 | 140·3 | 337·49 |
| 10 | 304·79 | 1·47 | −4·27 | −4·71 | 6·36 | 137·8 | 335·75 |
| 11 | 316·98 | 1·47 | −3·72 | −3·49 | 5·10 | 133·2 | 335·29 |
| 12 | 329·16 | 1·47 | −3·06 | −2·06 | 3·69 | 124·0 | 336·21 |
| 13 | 341·34 | 1·46 | −2·33 | −0·48 | 2·38 | 101·6 | 338·51 |
| 14 | 353·52 | 1·46 | −1·53 | +1·13 | 1·90 | 53·6 | 342·16 |
| 15 | 5·69 | 1·45 | −0·65 | +2·68 | 2·76 | 13·6 | 346·99 |
| 16 | 17·85 | 1·45 | +0·29 | +4·07 | 4·08 | 355·9 | 352·70 |
| 17 | 30·00 | 1·44 | +1·28 | +5·21 | 5·36 | 346·2 | 358·80 |
| 18 | 42·15 | 1·43 | +2·27 | +6·03 | 6·44 | 339·4 | 5·11 |
| 19 | 54·29 | 1·42 | +3·22 | +6·48 | 7·23 | 333·6 | 10·89 |
| 20 | 66·43 | 1·41 | +4·05 | +6·54 | 7·69 | 328·2 | 15·88 |
| 21 | 78·56 | 1·40 | +4·67 | +6·21 | 7·78 | 323·1 | 19·86 |
| 22 | 90·70 | 1·38 | +5·01 | +5·55 | 7·48 | 317·9 | 22·68 |
| 23 | 102·84 | 1·37 | +5·03 | +4·59 | 6·81 | 312·1 | 24·21 |
| 24 | 114·98 | 1·35 | +4·71 | +3·42 | 5·82 | 306·0 | 24·72 |
| 25 | 127·13 | 1·34 | +4·04 | +2·11 | 4·56 | 297·6 | 23·97 |
| 26 | 139·29 | 1·32 | +3·09 | +0·72 | 3·17 | 283·1 | 22·14 |
| 27 | 151·44 | 1·30 | +1·91 | −0·67 | 2·02 | 250·7 | 19·34 |
| 28 | 163·61 | 1·28 | +0·59 | −2·02 | 2·10 | 196·3 | 15·69 |
| Mar. 1 | 175·78 | 1·27 | −0·80 | −3·28 | 3·38 | 166·3 | 11·31 |
| 2 | 187 95 | 1·25 | −2·15 | −4·40 | 4·90 | 154·0 | 6·40 |
| 3 | 200·14 | 1·23 | −3·38 | −5·34 | 6·32 | 147·7 | 1·14 |
| 4 | 212·32 | 1·21 | −4·40 | −6·06 | 7·49 | 144·0 | 355·82 |
| 5 | 224·51 | 1·20 | −5·14 | −6·51 | 8·30 | 141·7 | 350·63 |
| 6 | 236·71 | 1·18 | −5·56 | −6·65 | 8·67 | 140·1 | 345 83 |
| 7 | 248·91 | 1·16 | −5·63 | −6·46 | 8·57 | 138·9 | 341·66 |
| 8 | 261·12 | 1·14 | −5·36 | −5·91 | 7 98 | 137·8 | 338 38 |
| 9 | 273·33 | 1·13 | −4·78 | −5·01 | 6·93 | 136·3 | 336·19 |
| 10 | 285·54 | 1·11 | −3·96 | −3·79 | 5·48 | 133·7 | 335·28 |
| 11 | 297·75 | 1·10 | −2·98 | −2·33 | 3·78 | 128·0 | 335·78 |
| 12 | 309·96 | 1·08 | −1·90 | −0·70 | 2·03 | 110·2 | 337 76 |
| 13 | 322·16 | 1·07 | −0·78 | +0·97 | 1·25 | 38 8 | 341·16 |
| 14 | 334 36 | +1·05 | +0·31 | +2·58 | 2·60 | 353·1 | 345·82 |

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|---|---|---|---|---|---|
| 21 | 59·56 | 0·90 | +4·98 | +5·82 | 7 |
| 22 | 71·71 | 0·88 | +4·90 | +4·91 | 6 |
| 23 | 83·87 | 0·85 | +4·57 | +3·77 | 5 |
| 24 | 96·03 | 0·83 | +3·97 | +2·46 | 4 |
| 25 | 108·19 | 0·80 | +3·13 | +1·06 | 3 |
| 26 | 120·35 | 0·77 | +2·08 | −0·38 | 2 |
| 27 | 132·52 | 0·75 | +0·86 | −1·77 | 1 |
| 28 | 144·69 | 0·72 | −0·48 | −3·08 | 3 |
| 29 | 156 87 | 0·69 | −1·85 | −4·26 | 4 |
| 30 | 169·05 | 0·66 | −3·18 | −5·25 | 6 |
| 31 | 181·24 | 0·64 | −4·40 | −6·03 | 7 |
| Apr. 1 | 193·43 | 0·61 | −5·42 | −6·55 | 8 |
| 2 | 205·63 | 0·59 | −6·17 | −6·78 | 9 |
| 3 | 217·83 | 0·56 | −6·59 | −6·69 | 9 |
| 4 | 230·04 | 0·54 | −6·63 | −6 25 | 9 |
| 5 | 242·26 | 0·51 | −6·27 | −5·46 | 8 |
| 6 | 254·48 | 0·49 | −5·53 | −4·33 | 7 |
| 7 | 266·71 | 0·47 | −4·45 | −2·90 | 5 |
| 8 | 278·93 | 0·45 | −3·12 | −1·26 | 3 |
| 9 | 291·16 | 0·42 | −1·61 | +0·48 | 1 |
| 10 | 303·39 | 0·40 | −0 05 | +2·20 | 2 |
| 11 | 315·61 | 0·38 | +1·47 | +3·77 | 4 |
| 12 | 327·83 | 0·35 | +2·85 | +5·07 | 5 |
| 13 | 340·03 | 0·33 | +4·04 | +6·04 | 7 |
| 14 | 352·23 | 0·30 | +4·96 | +6·61 | 8 |
| 15 | 4·43 | 0·28 | +5·60 | +6·8 | |

| Greenwich Midnight. | Selenographical Colong. of the Sun. | Lat. of the Sun. | Geocentric Libration Sel. Long. of the Earth. | Lat. of the Earth. | Combined Amount. | Direction. | C. |
|---|---|---|---|---|---|---|---|
| 1902. | ° | ° | ° | ° | ° | ° | ° |
| Apr. 22 | 89·68 | +0·07 | +2·71 | 0·00 | 2·71 | 270·0 | 21·24 |
| 23 | 101·86 | 0·04 | +1·51 | −1·43 | 2·08 | 226·6 | 18·08 |
| 24 | 114·04 | +0·01 | +0·22 | −2·77 | 2·78 | 184·5 | 14·10 |
| 25 | 126·22 | −0·02 | −1·14 | −4·00 | 4·16 | 164·1 | 9·49 |
| 26 | 138·40 | 0·05 | −2·49 | −5·05 | 5·63 | 153·8 | 4·45 |
| 27 | 150·59 | 0·08 | −3·80 | −5·88 | 7·00 | 147·1 | 359·21 |
| 28 | 162·78 | 0·11 | −5·00 | −6·47 | 8·18 | 142·3 | 354·00 |
| 29 | 174·98 | 0·14 | −6·03 | −6·79 | 9·08 | 138·4 | 349·05 |
| 30 | 187·18 | 0·16 | −6·81 | −6·79 | 9·61 | 134·9 | 344·58 |
| May 1 | 199·39 | 0·19 | −7·29 | −6·48 | 9·75 | 131·6 | 340·76 |
| 2 | 211·61 | 0·22 | −7·41 | −5·82 | 9·42 | 128·1 | 337·80 |
| 3 | 223·83 | 0·24 | −7·12 | −4·83 | 8·60 | 124·1 | 335·89 |
| 4 | 236·06 | 0·26 | −6·41 | −3·53 | 7·31 | 118·8 | 335·22 |
| 5 | 248·30 | 0·29 | −5·29 | −1·98 | 5·65 | 110·5 | 335·99 |
| 6 | 260·54 | 0·31 | −3·82 | −0·25 | 3·83 | 93·7 | 338·32 |
| 7 | 272·78 | 0·33 | −2·07 | +1·52 | 2·57 | 53·7 | 342·20 |
| 8 | 285·03 | 0·36 | −0·18 | +3·19 | 3·20 | 3·2 | 347·43 |
| 9 | 297·27 | 0·38 | +1·72 | +4·65 | 4·96 | 339·7 | 353·61 |
| 10 | 309·50 | 0·40 | +3·48 | +5·76 | 6·73 | 328·9 | 0·18 |
| 11 | 321·74 | 0·42 | +4·97 | +6·48 | 8·17 | 322·5 | 6·54 |
| 12 | 333·96 | 0·45 | +6·11 | +6·77 | 9·12 | 317·9 | 12·26 |
| 13 | 346·18 | 0·47 | +6·85 | +6·66 | 9·55 | 314·2 | 17·02 |
| 14 | 358·39 | 0·50 | +7·16 | +6·17 | 9·46 | 310·8 | 20·67 |
| 15 | 10·60 | 0·52 | +7·09 | +5·37 | 8·89 | 307·1 | 23·18 |
| 16 | 22·80 | 0·55 | +6·68 | +4·33 | 7·96 | 302·9 | 24·52 |
| 17 | 35·00 | 0·58 | +5·96 | +3·09 | 6·71 | 297·4 | 24·73 |
| 18 | 47·19 | 0·61 | +5·02 | +1·74 | 5·31 | 289·1 | 23·83 |
| 19 | 59·38 | 0·64 | +3·89 | +0·32 | 3·90 | 274·7 | 21·89 |
| 20 | 71·57 | 0·67 | +2·65 | −1·09 | 2·87 | 247·6 | 18·99 |
| 21 | 83·76 | 0·70 | +1·33 | −2·45 | 2·79 | 208·5 | 15·21 |
| 22 | 95·95 | 0·72 | −0·02 | −3·69 | 3·69 | 179·7 | 10·74 |
| 23 | 108·14 | 0·75 | −1·38 | −4·77 | 4·96 | 163·9 | 5·78 |
| 24 | 120·33 | 0·77 | −2·69 | −5·65 | 6·26 | 154·5 | 0·56 |
| 25 | 132·52 | 0·80 | −3·94 | −6·29 | 7·43 | 147·9 | 355·34 |
| 26 | 144·72 | 0·82 | −5·08 | −6·66 | 8·37 | 142·7 | 350·31 |
| 27 | 156·92 | 0·85 | −6·05 | −6·73 | 9·05 | 138·0 | 345·74 |
| 28 | 169·13 | 0·87 | −6·84 | −6·50 | 9·43 | 133·5 | 341·78 |
| 29 | 181·34 | −0·89 | −7·36 | −5·95 | 9·47 | 129·0 | 338·60 |

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|---|---|---|---|---|
| 4 | 254·74 | 1·00 | −2·73 | +2·50 |
| 5 | 266·99 | 1·01 | −0·74 | +4·04 |
| 6 | 279·25 | 1·03 | +1·33 | +5·30 |
| 7 | 291·50 | 1·05 | +3·32 | +6·17 |
| 8 | 303·75 | 1·07 | +5·06 | +6·61 |
| 9 | 315·99 | 1·08 | +6·42 | +6·61 |
| 10 | 328·23 | 1·10 | +7·30 | +6·20 |
| 11 | 340·46 | 1·12 | +7·69 | +5·46 |
| 12 | 352·68 | 1·14 | +7·61 | +4·45 |
| 13 | 4·90 | 1·16 | +7·13 | +3·24 |
| 14 | 17·11 | 1·18 | +6·31 | +1·91 |
| 15 | 29·32 | 1·20 | +5·23 | +0·53 |
| 16 | 41·52 | 1·22 | +3·99 | −0·87 |
| 17 | 53·73 | 1·24 | +2·65 | −2·21 |
| 18 | 65·92 | 1·26 | +1·26 | −3·45 |
| 19 | 78·12 | 1·27 | −0·10 | −4·54 |
| 20 | 90·31 | 1·29 | −1·41 | −5·44 |
| 21 | 102·51 | 1·31 | −2·63 | −6·10 |
| 22 | 114·70 | 1·32 | −3·76 | −6·50 |
| 23 | 126·90 | 1·34 | −4·75 | −6·61 |
| 24 | 139·10 | 1·35 | −5·60 | −6·42 |
| 25 | 151·31 | 1·36 | −6·28 | −5·92 |
| 26 | 163·51 | 1·37 | −6·76 | −5·13 |
| 27 | 175·72 | 1·38 | −6·98 | −4·06 |
| 28 | 187·94 | 1·39 | −6·91 | −2·75 |
| 29 | 200·17 | 1·40 | −6·50 | −1·25 |

| Greenwich Midnight. | Selenographical Colong. | Lat. of the Sun. | Geocentric Libration Sel. Long. of the Earth. | Lat. of the Earth. | Combined Amount. | Direction. | C. |
|---|---|---|---|---|---|---|---|
| 1902. | ° | ° | ° | ° | ° | ° | ° |
| July 7 | 298·16 | −1·45 | +6·03 | +6·23 | 8·68 | 315·9 | 18·25 |
| 8 | 310·41 | 1·46 | +7·00 | +5 55 | 8·93 | 308·4 | 21·74 |
| 9 | 322·65 | 1·47 | +7·47 | +4·57 | 8·76 | 301·5 | 23·90 |
| 10 | 334·88 | 1·48 | +7·44 | +3·38 | 8·17 | 294·4 | 24·79 |
| 11 | 347·11 | 1·49 | +6·97 | +2·05 | 7·26 | 286·4 | 24·47 |
| 12 | 359·33 | 1·49 | +6·14 | +0·65 | 6·17 | 276·0 | 23·02 |
| 13 | 11·55 | 1·50 | +5 05 | −0·74 | 5·10 | 261·7 | 20·56 |
| 14 | 23·76 | 1·51 | +3·77 | −2·08 | 4·31 | 241·1 | 17·20 |
| 15 | 35·97 | 1·51 | +2·41 | −3·32 | 4·10 | 216·0 | 13·07 |
| 16 | 48·18 | 1·52 | +1·04 | −4·41 | 4·53 | 193·3 | 8·33 |
| 17 | 60·38 | 1·52 | −0·28 | −5·31 | 5·32 | 177·0 | 3·20 |
| 18 | 72·58 | 1·53 | −1·51 | −5·99 | 6·18 | 165·8 | 357·91 |
| 19 | 84·77 | 1·53 | −2·60 | −6·41 | 6·92 | 157·9 | 352·70 |
| 20 | 96·96 | 1·53 | −3·55 | −6·54 | 7·44 | 151·5 | 347·83 |
| 21 | 109·16 | 1·53 | −4·33 | −6·37 | 7·70 | 145·8 | 343·50 |
| 22 | 121·35 | 1·53 | −4·97 | −5·89 | 7·71 | 139·8 | 339·94 |
| 23 | 133·54 | 1·53 | −5·43 | −5·12 | 7·46 | 133·3 | 337·27 |
| 24 | 145·74 | 1·53 | −5·72 | −4·08 | 7·03 | 125·5 | 335·65 |
| 25 | 157·94 | 1·53 | −5·82 | −2·81 | 6·46 | 115·8 | 335·19 |
| 26 | 170·15 | 1·52 | −5·70 | −1·36 | 5·86 | 103·4 | 335·99 |
| 27 | 182·36 | 1·52 | −5·31 | +0·19 | 5·31 | 88·0 | 338·13 |
| 28 | 194·58 | 1·51 | −4·64 | +1·77 | 4·97 | 69·1 | 341·61 |
| 29 | 206·81 | 1·51 | −3·65 | +3·26 | 4·90 | 48·2 | 346·35 |
| 30 | 219·05 | 1·50 | −2·36 | +4·58 | 5·15 | 27·3 | 352·13 |
| 31 | 231·29 | 1·49 | −0·83 | +5·61 | 5·67 | 8·4 | 358·54 |
| Aug. 1 | 243·53 | 1·49 | +0·86 | +6·28 | 6·34 | 352·2 | 5·07 |
| 2 | 255·79 | 1·48 | +2·56 | +6·52 | 7·00 | 338·6 | 11·19 |
| 3 | 268·04 | 1·48 | +4·11 | +6·33 | 7·55 | 327·0 | 16·42 |
| 4 | 280·29 | 1·47 | +5·39 | +5·73 | 7·86 | 316·8 | 20·49 |
| 5 | 292·54 | 1·47 | +6·28 | +4·80 | 7·91 | 307·4 | 23·22 |
| 6 | 304·78 | 1·47 | +6·71 | +3·61 | 7·62 | 298·3 | 24·62 |
| 7 | 317·02 | 1·46 | +6·69 | +2·26 | 7·06 | 288·7 | 24·73 |
| 8 | 329·25 | 1·46 | +6·25 | +0·84 | 6·31 | 277·7 | 23·62 |
| 9 | 341·48 | 1·45 | +5·44 | −0·59 | 5·47 | 263·8 | 21·43 |
| 10 | 353·70 | 1·45 | +4·38 | −1·96 | 4·80 | 245·9 | 18·29 |
| 11 | 5·92 | 1·44 | +3·13 | −3·23 | 4·50 | 224·1 | 14·33 |
| 12 | 18·13 | 1·43 | +1·79 | −4·35 | 4·71 | 202·4 | 9·75 |
| 13 | 30·33 | −1·43 | +0·46 | −5·28 | 5·30 | 185·0 | 4·71 |

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|---|---|---|---|---|---|
| | 19 | 103·47 | 1·36 | −4·55 | −5·2 |
| | 20 | 115·65 | 1 34 | −4·70 | −4·2 |
| | 21 | 127·84 | 1·33 | −4·68 | −2 9 |
| | 22 | 140 03 | 1·31 | −4·49 | −1·46 |
| | 23 | 152·22 | 1·29 | −4·13 | +0·10 |
| | 24 | 164·42 | 1·27 | −3·59 | +1·68 |
| | 25 | 176·62 | 1·26 | −2·87 | +3·18 |
| | 26 | 188·83 | 1·24 | −1·96 | +4·50 |
| | 27 | 201·04 | 1·22 | −0·88 | +5·56 |
| | 28 | 213 27 | 1·20 | +0·35 | +6·28 |
| | 29 | 225·50 | 1·19 | +1·64 | +6·60 |
| | 30 | 237·73 | 1·17 | +2·92 | +6·50 |
| | 31 | 249·97 | 1·15 | +4·08 | +6·00 |
| Sept. | 1 | 262·22 | 1·14 | +4·98 | +5·14 |
| | 2 | 274·46 | 1·12 | +5·59 | +3·98 |
| | 3 | 286·70 | 1·11 | +5 83 | +2·63 |
| | 4 | 298·93 | 1·09 | +5·70 | +1·18 |
| | 5 | 311·16 | 1·08 | +5·21 | −0·31 |
| | 6 | 323·38 | 1·06 | +4·41 | −1·74 |
| | 7 | 335·60 | 1·04 | +3·36 | −3·07 |
| | 8 | 347·81 | 1·02 | +2·15 | −4·24 |
| | 9 | 0·02 | 1·01 | +0·83 | −5·23 |
| | 10 | 12·22 | 0·99 | −0·46 | −5·99 |
| | 11 | 24·41 | 0·97 | −1·68 | −6·49 |
| | 12 | 36·61 | 0·95 | −2·76 | −6·72 |
| | 13 | 48·79 | 0·93 | −2·62 | −6·6 |

| Greenwich Midnight. | Selenographical Colong. of the Sun. | Lat. of the Sun. | Geocentric Libration Sel. Long of the Earth. | Lat. of the Earth. | Combined Amount. | Direction. | C. |
|---|---|---|---|---|---|---|---|
| 1902. | ° | ° | ° | ° | ° | ° | ° |
| Sept. 21 | 146·17 | −0·72 | −1·86 | +3·04 | 3·57 | 31·5 | 341·04 |
| 22 | 158·35 | 0·69 | −0·89 | +4·42 | 4·51 | 11·4 | 349·31 |
| 23 | 170·53 | 0·66 | +0·14 | +5·54 | 5·54 | 358·6 | 355·30 |
| 24 | 182·73 | 0·64 | +1·18 | +6·31 | 6·42 | 349·4 | 1·58 |
| 25 | 194·93 | 0·61 | +2·21 | +6·70 | 7·06 | 341·7 | 7·70 |
| 26 | 207 14 | 0·59 | +3·16 | +6·68 | 7·39 | 334·7 | 13·24 |
| 27 | 219·35 | 0·56 | +4·01 | +6·27 | 7·44 | 327·4 | 17·90 |
| 28 | 231·57 | 0·54 | +4·67 | +5·49 | 7·21 | 319·6 | 21·45 |
| 29 | 243·79 | 0·52 | +5·13 | +4·40 | 6 76 | 310·6 | 23·75 |
| 30 | 256·01 | 0·50 | +5·32 | +3·09 | 6·15 | 300·2 | 24·79 |
| Oct. 1 | 268·24 | 0·47 | +5·24 | +1·64 | 5·49 | 287·4 | 24·56 |
| 2 | 280·46 | 0·45 | +4·88 | +0·13 | 4·88 | 271·5 | 23·12 |
| 3 | 292·68 | 0·43 | +4·25 | −1·34 | 4·46 | 252·5 | 20·59 |
| 4 | 304·90 | 0·40 | +3·37 | −2·75 | 4·35 | 230·8 | 17·10 |
| 5 | 317·11 | 0·38 | +2·29 | −4·00 | 4·61 | 209 8 | 12·84 |
| 6 | 329·32 | 0·35 | +1·08 | −5·05 | 5·18 | 192·1 | 8 03 |
| 7 | 341·52 | 0·33 | −0·22 | −5·89 | 5·89 | 177·9 | 2·88 |
| 8 | 353 72 | 0·30 | −1·51 | −6·48 | 6·65 | 166·9 | 357·62 |
| 9 | 5·91 | 0·28 | −2·74 | −6·78 | 7·31 | 158·0 | 352·48 |
| 10 | 18·09 | 0·25 | −3 83 | −6 80 | 7·81 | 150 6 | 347·67 |
| 11 | 30 27 | 0 22 | −4·69 | −6·50 | 8·01 | 144 2 | 343·38 |
| 12 | 42·45 | 0·19 | −5·29 | −5·90 | 7·93 | 138·1 | 339·81 |
| 13 | 54·61 | 0·16 | −5·57 | −4·98 | 7·47 | 131·8 | 337·12 |
| 14 | 66·77 | 0·13 | −5·51 | −3·78 | 6·68 | 124·4 | 335·52 |
| 15 | 78·93 | 0·10 | −5·09 | −2·34 | 5·60 | 114·7 | 335·17 |
| 16 | 91·08 | 0·07 | −4·35 | −0·72 | 4·41 | 99 4 | 336·21 |
| 17 | 103·23 | 0·04 | −3 32 | +0·97 | 3·46 | 73·7 | 338·69 |
| 18 | 115·38 | −0·01 | −2·18 | +2·63 | 3·42 | 39·7 | 342·60 |
| 19 | 127·53 | +0·03 | −0·72 | +4·12 | 4·18 | 9·9 | 347·73 |
| 20 | 139·69 | 0·06 | +0 68 | +5 35 | 5·39 | 352·8 | 353·73 |
| 21 | 151·85 | 0·09 | +2·02 | +6·23 | 6·55 | 342·0 | 0·11 |
| 22 | 164·02 | 0·12 | +3·23 | +6·70 | 7·44 | 334·3 | 6 38 |
| 23 | 176·19 | 0·15 | +4·24 | +6·76 | 7·98 | 327 9 | 12·11 |
| 24 | 188·38 | 0 17 | +5·03 | +6·42 | 8·16 | 321·9 | 16·95 |
| 25 | 200·57 | 0·20 | +5·55 | +5·72 | 7·97 | 315·9 | 20·72 |
| 26 | 212·76 | 0·22 | +5·82 | +4·70 | 7·48 | 308·9 | 23·31 |
| 27 | 224·96 | 0·25 | +5·84 | +3·46 | 6·79 | 300·7 | 24·66 |
| 28 | 237·16 | +0·27 | +5·61 | +2·05 | 5·97 | 290·1 | 24·77 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | +0·44 | −5·07 | |
| 4 | 322·58 | 0·44 | −1·06 | −6·32 | |
| 5 | 334·77 | 0·47 | −2·37 | −6·70 | |
| 6 | 346·96 | 0·49 | −3·62 | −6·80 | |
| 7 | 359·14 | 0·52 | −4·75 | −6·60 | |
| 8 | 11·31 | 0·55 | −5·69 | −6·11 | |
| 9 | 23·48 | 0·58 | −6·37 | −5·32 | |
| 10 | 35·64 | 0·60 | −6·73 | −4·25 | |
| 11 | 47·80 | 0·63 | −6·69 | −2·92 | |
| 12 | 59·94 | 0·66 | −6·23 | −1·39 | |
| 13 | 72·08 | 0·69 | −5·33 | +0·27 | . |
| 14 | 84·22 | 0·72 | −4·04 | +1·96 | 4 |
| 15 | 96·35 | 0·75 | −2·42 | +3·55 | 4 |
| 16 | 108·48 | 0·78 | −0·60 | +4·91 | 4 |
| 17 | 120·62 | 0·80 | +1·27 | +5·93 | 6 |
| 18 | 132·76 | 0·83 | +3·05 | +6·54 | 7 |
| 19 | 144·90 | 0·85 | +4·59 | +6·70 | 8 |
| 20 | 157·05 | 0·87 | +5·79 | +6·44 | 8 |
| 21 | 169·21 | 0·90 | +6·61 | +5·80 | 8 |
| 22 | 181·38 | 0·92 | +7·03 | +4·84 | 8 |
| 23 | 193·56 | 0·94 | +7·08 | +3·65 | 7 |
| 24 | 205·74 | 0·96 | +6·80 | +2·29 | 7 |
| 25 | 217·92 | 0·98 | +6·25 | +0·85 | 6 |
| 26 | 230·10 | 0·99 | +5·48 | −0·61 | 5 |
| 27 | 242·29 | [illegible] | | | |

| Greenwich Midnight. | Selenographical Colong. | Lat. of the Sun. | Geocentric Libration Sel. Long. of the Earth. | Lat. | Combined Amount. | Direction. | O. |
|---|---|---|---|---|---|---|---|
| 1902. Dec. 6 | 351°·97 | +1°·18 | −6°·21 | −5°·41 | 8°·24 | 131°·1 | 338°·84 |
| 7 | 4·13 | 1·20 | −6·99 | −4·45 | 8·29 | 122·5 | 336 57 |
| 8 | 16·29 | 1·22 | −7·48 | −3·25 | 8·16 | 113·5 | 335·31 |
| 9 | 28·44 | 1·24 | −7·60 | −1·84 | 7·82 | 103·6 | 335·23 |
| 10 | 40·59 | 1·26 | −7·28 | −0·29 | 7·29 | 92·3 | 336·44 |
| 11 | 52·73 | 1·28 | −6·47 | +1·33 | 6·61 | 78·4 | 339·07 |
| 12 | 64·86 | 1·29 | −5·18 | +2·91 | 5·94 | 60·7 | 343·15 |
| 13 | 76·99 | 1·31 | −3·46 | +4·34 | 5·55 | 38·6 | 348·56 |
| 14 | 89·11 | 1·33 | −1·41 | +5·49 | 5·67 | 14·4 | 354·93 |
| 15 | 101·23 | 1·35 | +0·77 | +6·25 | 6·30 | 353·0 | 1·72 |
| 16 | 113·35 | 1·36 | +2·91 | +6·56 | 7·17 | 336·1 | 8·31 |
| 17 | 125·48 | 1·37 | +4·80 | +6·41 | 8·01 | 323·2 | 14·13 |
| 18 | 137·62 | 1·39 | +6·29 | +5·83 | 8·58 | 312·8 | 18·81 |
| 19 | 149·76 | 1·40 | +7·31 | +4·91 | 8·81 | 303·9 | 22·18 |
| 20 | 161·91 | 1·41 | +7·83 | +3·73 | 8·68 | 295·5 | 24·18 |
| 21 | 174·06 | 1·41 | +7·87 | +2·39 | 8·23 | 286·9 | 24·89 |
| 22 | 186·22 | 1·42 | +7·50 | +0·96 | 7·56 | 277·3 | 24·36 |
| 23 | 198·39 | 1·43 | +6·81 | −0·48 | 6·83 | 266 0 | 22·69 |
| 24 | 210·56 | 1·43 | +5·87 | −1·87 | 6·16 | 252·3 | 20·00 |
| 25 | 222·74 | 1·44 | +4·76 | −3·16 | 5·72 | 236·4 | 16·43 |
| 26 | 234·92 | 1·45 | +3·54 | −4·29 | 5·56 | 219·5 | 12·10 |
| 27 | 247·10 | 1·45 | +2·26 | −5·22 | 5·69 | 203·4 | 7·23 |
| 28 | 259·29 | 1·46 | +0·97 | −5·93 | 6·01 | 189·3 | 2·04 |
| 29 | 271·47 | 1·47 | −0·33 | −6·37 | 6·38 | 177·0 | 356·77 |
| 30 | 283·66 | 1·47 | −1·60 | −6·55 | 6·74 | 166·3 | 351·68 |
| 31 | 295·85 | 1·48 | −2·83 | −6·43 | 7·03 | 156·2 | 346·99 |
| 1903. Jan. 1 | 308·03 | +1·48 | −4·01 | −6·04 | 7·25 | 146·4 | 342·88 |

The longitudes are reckoned in the plane of the Moon's equator, the axis of reference being the radius which passes through the mean centre of the visible disc. This axis therefore rotates with the Moon, and is not fixed in space.

The inclination of the Moon's equator to the ecliptic is taken as 1°·523, the value used in the *Connaissance des Temps*, that given by the *Nautical Almanac* being 1°·536.

The physical librations in longitude and latitude, as given by Professor Franz's formulæ, have been applied; their values are taken from the *Berliner Jahrbuch* for the days given there, and interpolated by a graphical method for the other days. But the signs in the *Jahrbuch* require to be reversed in order to reduce to the system used here.

The colongitude of the Sun is 90° (or 450°) *minus* his selenographical longitude. It also is the selenographical longitude of the morning terminator reckoned eastward from the mean centre of the disc. Hence its value is approximately 270°, 0°, 90°, 180° at new Moon, first quarter, full Moon, last quarter respectively. The longitude of the evening terminator is of course 180° greater or less than that of the morning one.

When the geocentric libration in longitude is positive, the region brought into view is on the west limb; when negative, on the east.

When the geocentric libration in latitude is positive, the region brought into view is at the Moon's north pole; when negative, at the south.

The column "Combined Amount" gives the distance between the apparent and mean centres of the disc, and the column "Direction" gives the position-angle of the apparent centre from the mean centre, or, which is the same thing, the position-angle of the region which is most carried into view by libration. The angles are reckoned eastward from the northern extremity of the Moon's axis.

C denotes the geocentric position-angle of the northern extremity of the Moon's axis measured eastward from the northernmost point of the disc. It has been computed by the second formula given in the Preface to the *Nautical Almanac*, but the co-ordinates of the Moon's equator have been taken from the *Connaissance des Temps*, so as to make this column consistent with the rest of the ephemeris.

The terms "East" and "West" are used throughout with reference to our sky, and not as they would appear to an observer on the Moon.

I give the method for finding the altitude of the Sun at a given point on the Moon whose position is defined: (1) by selenographical longitude and latitude; (2) by direction cosines.

In either case the Sun's selenographical colongitude and latitude (K, L supposed) must be found by interpolation from the ephemeris for the given time.

In the first case let the given point be in the position longitude M, latitude N. Longitudes are reckoned from the meridian passing through the mean centre of the disc, and the positive direction is that towards Mare Crisium. North latitudes are considered positive.

Then

$$\text{sine Sun's altitude} = \sin L \sin N + \cos L \cos N \sin (K + M).$$

In the second case let $\xi$, $\eta$, $\zeta$ be the direction cosines of the given point. The axes are (1) that diameter of the Moon's equator which is 90° from the mean centre of the disc; (2) the Moon's polar axis; (3) the diameter through the mean centre of the disc. The positive directions are as above. Mr. Saunder

has issued some maps of portions of the Moon's surface from which the co-ordinates $\xi$, $\eta$, $\zeta$ can be taken at sight.

Then the Sun's direction cosines are :

$$\cos K \cos L, \sin L, \sin K \cos L,$$

and sine Sun's altitude

$$= \xi \cos K \cos L + \eta \sin L + \zeta \sin K \cos L.$$

Neither formula is convenient when the Sun's altitude is very great, for an angle near 90° cannot be accurately determined from its sine. However, when the Sun is high the shadows are so inconspicuous that it is not necessary to compute his altitude with great accuracy.

*Benvenue*, 55 *Ulundi Road*, *Blackheath*, *S.E.*
1901 *September* 21.

## *Ephemeris for Physical Observat*

| P. | L−O. | B. | Apparent Diameter. Equat. 2a. | Defect. | Polar 2b. | d. | Q. |
|---|---|---|---|---|---|---|---|
| 44°765 | 167°836 | −0°822 | 33″46 | 0″07 | 31″31 | 5°31 | 255°9 |
| 44·604 | 168·275 | −0·803 | 33·55 | ·08 | 31·39 | 5·57 | 255·7 |
| 44·446 | 168·712 | −0·785 | 33·65 | ·09 | 31·48 | 5·84 | 255·6 |
| 44·290 | 169·145 | −0·767 | 33·74 | ·10 | 31·57 | 6·10 | 255·5 |
| 44·137 | 169·573 | −0·749 | 33·85 | ·10 | 31·67 | 6·36 | 255·4 |
| 43·987 | 169·999 | −0·731 | 33·96 | ·11 | 31·77 | 6·61 | 255·3 |
| 43·839 | 170·420 | −0·713 | 34·07 | ·12 | 31·87 | 6·86 | 255·1 |
| 43·694 | 170·837 | −0·695 | 34·19 | ·13 | 31·98 | 7·11 | 255·0 |
| 43·551 | 171·249 | −0·677 | 34·31 | ·14 | 32·10 | 7·35 | 254·9 |
| 43·410 | 171·656 | −0·659 | 34·44 | ·15 | 32·22 | 7·59 | 254·8 |
| 43·272 | 172·059 | −0·641 | 34·58 | ·16 | 32·35 | 7·82 | 254·7 |
| 43·137 | 172·456 | −0·623 | 34·72 | ·17 | 32·48 | 8·04 | 254·6 |
| 43·004 | 172·849 | −0·605 | 34·86 | ·18 | 32·61 | 8·27 | 254·5 |
| 42·874 | 173·234 | −0·587 | 34·99 | ·19 | 32·74 | 8·48 | 254·4 |
| 42·748 | 173·615 | −0·570 | 35·14 | ·20 | 32·87 | 8·69 | 254·3 |
| 42·624 | 173·990 | −0·552 | 35·29 | ·21 | 33·02 | 8·89 | 254·2 |
| 42·502 | 174·358 | −0·535 | 35·45 | ·22 | 33·17 | 9·09 | 254·1 |

*Jupiter*, 1902–3. By A. C. D. Crommelin.

| Greenwich Noon. 1902. | Longitude of ♃'s Central Meridian. 877°90 I. | 870°27 II. | Corr. for Phase. | Light-time. | A−O. | *B.* |
|---|---|---|---|---|---|---|
| | ° | ° | ° | m | ° | ° |
| Feb. 21 | 170·69 | 346·30 | +0·12 | 49·645 | 162·528 | −0·920 |
| 23 | 126·13 | 286·48 | ·14 | 49·513 | | |
| 25 | 81·58 | 226·67 | ·15 | 49·375 | | |
| 27 | 37·04 | 166·86 | ·16 | 49·232 | | |
| Mar. 1 | 352·50 | 107·06 | ·18 | 49·079 | | |
| 3 | 307·97 | 47·27 | ·19 | 48·921 | 163·382 | −0·877 |
| 5 | 263·45 | 347·49 | ·20 | 48·759 | | |
| 7 | 218·94 | 287·72 | ·22 | 48·592 | | |
| 9 | 174·43 | 227·95 | ·24 | 48·419 | | |
| 11 | 129·93 | 168·19 | ·25 | 48·240 | | |
| 13 | 85·44 | 108·44 | ·27 | 48·055 | 164·239 | −0·833 |
| 15 | 40·96 | 48·70 | ·28 | 47·866 | | |
| 17 | 356·49 | 348·97 | ·30 | 47·672 | | |
| 19 | 312·02 | 289·24 | ·31 | 47·474 | | |
| 21 | 267·56 | 229·52 | ·33 | 47·271 | | |
| 23 | 223·11 | 169·81 | ·34 | 47·062 | 165·097 | −0·788 |
| 25 | 178·67 | 110·11 | ·36 | 46·849 | | |
| 27 | 134·24 | 50·42 | ·38 | 46·632 | | |
| 29 | 89·82 | 350·74 | ·39 | 46·413 | | |
| 31 | 45·41 | 291·07 | ·40 | 46·189 | | |
| Apr. 2 | 1·01 | 231·40 | ·42 | 45·958 | 165·956 | −0·744 |
| 4 | 316·62 | 171·75 | ·43 | 45·725 | | |
| 6 | 272·24 | 112·11 | ·45 | 45·489 | | |
| 8 | 227·86 | 52·47 | ·46 | 45·250 | | |
| 10 | 183·49 | 352·84 | ·47 | 45·008 | | |
| 12 | 139·14 | 293·22 | ·48 | 44·763 | 166·816 | −0·699 |
| 14 | 94·80 | 233·62 | ·49 | 44·515 | | |
| 16 | 50·47 | 174·03 | ·51 | 44·265 | | |
| 18 | 6·14 | 114·44 | ·52 | 44·013 | | |
| 20 | 321·82 | 54·86 | ·53 | 43·759 | | |
| 22 | 277·52 | 355·30 | ·54 | 43·502 | 167·676 | −0·654 |
| 24 | 233·23 | 295·75 | ·54 | 43·242 | | |
| 26 | 188·95 | 236·21 | ·55 | 42·982 | | |
| 28 | 144·68 | 176·68 | ·55 | 42·722 | | |
| 30 | 100·41 | 117·15 | +0·56 | 42·460 | | |

| P. | L−O. | B. | Apparent Diameter. Equat. 2a. | Defect. | Polar 2b. | d. | Q. |
|---|---|---|---|---|---|---|---|
| ° | ° | ° | ″ | ″ | ″ | ° | ° |
| 40·775 | 179·908 | −0·228 | 39·37 | 0·38 | 36·83 | 11·37 | 252·7 |
| 40·716 | 180·109 | −0·214 | 39·62 | ·39 | 37·06 | 11·40 | 252·7 |
| 40·660 | 180·298 | −0·200 | 39·87 | ·39 | 37·29 | 11·42 | 252·6 |
| 40·608 | 180·477 | −0·187 | 40·12 | ·40 | 37·53 | 11·42 | 252·6 |
| 40·559 | 180·645 | −0·174 | 40·38 | ·40 | 37·77 | 11·42 | 252·6 |
| 40·513 | 180·801 | −0·161 | 40·64 | ·40 | 38·01 | 11·40 | 252·5 |
| 40·471 | 180·947 | −0·148 | 40·90 | ·40 | 38·26 | 11·37 | 252·5 |
| 40·432 | 181·081 | −0·136 | 41·16 | ·40 | 38·51 | 11·33 | 252·5 |
| 40·397 | 181·203 | −0·124 | 41·43 | ·40 | 38·76 | 11·28 | 252·5 |
| 40·365 | 181·312 | −0·113 | 41·70 | ·40 | 39·01 | 11·22 | 252·5 |
| 40·337 | 181·410 | −0·102 | 41·97 | ·40 | 39·26 | 11·14 | 252·5 |
| 40·312 | 181·496 | −0·091 | 42·25 | ·39 | 39·51 | 11·06 | 252·5 |
| 40·291 | 181·569 | −0·080 | 42·52 | ·39 | 39·77 | 10·96 | 252·5 |
| 40·273 | 181·631 | −0·070 | 42·79 | ·38 | 40·03 | 10·85 | 252·5 |
| 40·258 | 181·679 | −0·060 | 43·06 | ·38 | 40·29 | 10·72 | 252·5 |
| 40·247 | 181·715 | −0·051 | 43·34 | ·37 | 40·55 | 10·59 | 252·5 |
| 40·240 | 181·739 | −0·042 | 43·62 | ·36 | 40·81 | 10·44 | 252·5 |
| 40·236 | 181·749 | −0·034 | 43·89 | ·35 | 41·07 | 10·27 | 252·5 |
| 40·236 | 181·746 | −0·026 | 44·16 | ·34 | 41·32 | 10·10 | 252·6 |
| 40·239 | 181·731 | −0·018 | 44·43 | ·33 | 41·57 | 9·91 | 252·6 |

| Greenwich Noon. 1902. | | Longitude of ℳ's Central Meridian. 877°·90 I. | 870°·27 II. | Corr. for Phase. | Light-time. | A−O. | B. |
|---|---|---|---|---|---|---|---|
| | | ° | ° | ° | m | ° | ° |
| May | 2 | 56·16 | 57·63 | +0·56 | 42·197 | 168·539 | −0·609 |
| | 4 | 11·92 | 358·13 | ·56 | 41·933 | | |
| | 6 | 327·69 | 298·64 | ·57 | 41·670 | | |
| | 8 | 283·47 | 239·16 | ·57 | 41·407 | | |
| | 10 | 239·26 | 179·69 | ·57 | 41·144 | | |
| | 12 | 195·07 | 120·23 | ·56 | 40·881 | 169·401 | −0·563 |
| | 14 | 150·88 | 60·78 | ·56 | 40·618 | | |
| | 16 | 106·71 | 1·35 | ·56 | 40·356 | | |
| | 18 | 62·55 | 301·93 | ·55 | 40·097 | | |
| | 20 | 18·40 | 242·52 | ·55 | 39·839 | | |
| | 22 | 334·26 | 183·11 | ·54 | 39·581 | 170·266 | −0·518 |
| | 24 | 290·13 | 123·72 | ·53 | 39·325 | | |
| | 26 | 246·01 | 64·34 | ·52 | 39·072 | | |
| | 28 | 201·90 | 4·97 | ·51 | 38·823 | | |
| | 30 | 157·80 | 305·61 | ·50 | 38·576 | | |
| June | 1 | 113·71 | 246·26 | ·49 | 38·331 | 171·131 | −0·472 |
| | 3 | 69·63 | 186·92 | ·47 | 38·090 | | |
| | 5 | 25·56 | 127·59 | ·46 | 37·853 | | |
| | 7 | 341·51 | 68·27 | ·44 | 37·619 | | |
| | 9 | 297·47 | 8·96 | ·43 | 37·390 | | |
| | 11 | 253·44 | 309·67 | ·41 | 37·165 | 172·000 | −0·426 |
| | 13 | 209·41 | 250·38 | ·39 | 36·945 | | |
| | 15 | 165·39 | 191·10 | ·37 | 36·730 | | |
| | 17 | 121·38 | 131·83 | ·35 | 36·520 | | |
| | 19 | 77·39 | 72·58 | ·33 | 39·316 | | |
| | 21 | 33·40 | 13·34 | ·31 | 36·117 | 172·867 | −0·380 |
| | 23 | 349·42 | 314·10 | ·29 | 35·925 | | |
| | 25 | 305·45 | 254·87 | ·28 | 35·740 | | |
| | 27 | 261·49 | 195·65 | ·26 | 35·561 | | |
| | 29 | 217·53 | 136·43 | ·24 | 35·389 | | |
| July | 1 | 173·58 | 77·21 | ·21 | 35·223 | 173·736 | −0·333 |
| | 3 | 129·63 | 18·00 | ·19 | 35·065 | | |
| | 5 | 85·69 | 318·80 | ·17 | 34·915 | | |
| | 7 | 41·76 | 259·61 | ·16 | 34·773 | | |
| | 9 | 357·84 | 200·42 | ·14 | 34·639 | | |
| | 11 | 313·91 | 141·23 | ·12 | 34·513 | 174·606 | −0·287 |
| | 13 | 269·99 | 82·05 | ·10 | 34·395 | | |
| | 15 | 226·07 | 22·87 | +0·09 | 34·288 | | |

| P. | ☉—☉ | B. | Apparent Diameter. Equat. 2a. | Defect. | Polar 2b. | d. | Q. |
|---|---|---|---|---|---|---|---|
| | ° | ° | ″ | ″ | ″ | ° | ° |
| 40·952 | 179·200 | +0·037 | 48·59 | 0·06 | 45·46 | 4·07 | 255·14 |
| 41·020 | 178·972 | +0·035 | 48·72 | ·05 | 45·58 | 3·67 | 255·50 |
| 41·091 | 178·735 | +0·033 | 48·84 | ·04 | 45·69 | 3·26 | 255·93 |
| 41·163 | 178·494 | +0·030 | 48·94 | ·03 | 45·79 | 2·84 | 256·45 |
| 41·237 | 178·248 | +0·027 | 49·03 | ·02 | 45·87 | 2·42 | 257·12 |
| 41·313 | 177·998 | +0·024 | 49·10 | ·01 | 45·94 | 2·00 | 258·16 |
| 41·390 | 177·743 | +0·020 | 49·16 | ·01 | 46·00 | 1·58 | 259·57 |
| 41·467 | 177·486 | +0·016 | 49·21 | ·01 | 46·05 | 1·15 | 263·72 |
| 41·546 | 177·227 | +0·012 | 49·25 | ·00 | 46·08 | 0·72 | 268·54 |
| 41·625 | 176·967 | +0·008 | 49·27 | ·00 | 46·10 | 0·32 | 287·32 |
| 41·706 | 176·706 | +0·003 | 49·28 | ·00 | 46·10 | 0·25 | 27·59 |
| 41·787 | 176·445 | −0·002 | 49·27 | ·00 | 46·10 | 0·63 | 57·32 |
| 41·867 | 176·186 | −0·007 | 49·24 | ·00 | 46·07 | 1·06 | 64·08 |
| 41·948 | 175·928 | −0·012 | 49·20 | ·01 | 46·04 | 1·49 | 66·98 |
| 42·028 | 175·674 | −0·017 | 49·15 | ·01 | 45·99 | 1·91 | 68·62 |
| 42·109 | 175·422 | −0·023 | 49·08 | ·02 | 45·93 | 2·33 | 69·72 |
| 42·188 | 175·174 | −0·029 | 49·00 | ·03 | 45·86 | 2·76 | 70·47 |
| 42·266 | 174·932 | −0·035 | 48·90 | ·04 | 45·77 | 3·17 | 71·04 |
| 42·342 | 174·694 | −0·041 | 48·80 | ·05 | 45·67 | 3·59 | 71·51 |
| 42·417 | 174·463 | −0·048 | 48·69 | ·06 | 45·56 | 3·99 | 71·88 |

| Greenwich Noon. 1902. | Longitude of ℣'s Central Meridian. 877°·90 I. | 870°·27 II. | Corr. for Phase. | Light-time. | A−O. | B. |
|---|---|---|---|---|---|---|
| | ° | ° | ° | m | ° | ° |
| July 17 | 182·15 | 323·69 | +0·07 | 34·190 | | |
| 19 | 138·24 | 264·52 | ·06 | 34·100 | | |
| 21 | 94·32 | 205·34 | ·05 | 34·019 | 175·478 | −0·241 |
| 23 | 50·40 | 146·16 | ·04 | 33·947 | | |
| 25 | 6·49 | 86·99 | ·03 | 33·884 | | |
| 27 | 322·57 | 27·81 | ·02 | 33·831 | | |
| 29 | 278 65 | 328·63 | ·01 | 33·788 | | |
| 31 | 234 73 | 269·45 | + ·01 | 33·754 | 176·350 | −0·194 |
| Aug. 2 | 190·80 | 210·26 | ·00 | 33·730 | | |
| 4 | 146·87 | 151·07 | ·00 | 33·716 | | |
| 6 | 102·93 | 91·88 | ·00 | 33·712 | | |
| 8 | 58·99 | 32·67 | ·00 | 33·718 | | |
| 10 | 15·04 | 333·46 | ·00 | 33·734 | 177·223 | −0·146 |
| 12 | 331·08 | 274·24 | − ·01 | 33·760 | | |
| 14 | 287·11 | 215·01 | ·02 | 33·796 | | |
| 16 | 243·14 | 155·78 | ·02 | 33·842 | | |
| 18 | 199·16 | 96·54 | ·03 | 33·897 | | |
| 20 | 155·16 | 37·28 | ·04 | 33·961 | 178·097 | −0·099 |
| 22 | 111·15 | 338·01 | ·06 | 34·035 | | |
| 24 | 67·13 | 278·73 | ·07 | 34·118 | | |
| 26 | 23·10 | 219·44 | ·08 | 34·212 | | |
| 28 | 339·06 | 160·14 | ·10 | 34·312 | | |
| 30 | 295·00 | 100·82 | ·12 | 34·422 | 178·972 | −0·052 |
| Sept. 1 | 250·93 | 41·49 | ·13 | 34 541 | | |
| 3 | 206·84 | 342·15 | ·15 | 34·669 | | |
| 5 | 162·74 | 282·79 | ·17 | 34·804 | | |
| 7 | 118·62 | 223·41 | ·19 | 34 948 | | |
| 9 | 74·49 | 164·02 | ·21 | 35·100 | 179·849 | −0·005 |
| 11 | 30·34 | 104·61 | ·23 | 35·259 | | |
| 13 | 346·18 | 45·19 | ·25 | 35·426 | | |
| 15 | 302 00 | 345·75 | ·27 | 35 601 | | |
| 17 | 257 81 | 286·30 | ·29 | 35·780 | | |
| 19 | 213·60 | 226·83 | ·31 | 35·967 | 180·727 | +0·042 |
| 21 | 169·37 | 167·34 | ·33 | 36 159 | | |
| 23 | 125·12 | 107·84 | ·35 | 36·360 | | |
| 25 | 80·86 | 48·32 | ·37 | 36·565 | | |
| 27 | 36 59 | 348·79 | ·39 | 36·775 | | |
| 29 | 352·30 | 289·24 | −0·41 | 36·991 | 181·607 | +0·089 |

| P | L − O. | B. | Apparent Diameter. Equat. 2″. | Defect. | Polar 2b. | d. | Q. |
|---|---|---|---|---|---|---|---|
| ° | ° | ° | ″ | ″ | ″ | ° | ° |
| 3·267 | 171·915 | −0·141 | 44·65 | 0·33 | 41·77 | 9·88 | 74·65 |
| 3·272 | 171·902 | −0·143 | 44·38 | ·34 | 41·52 | 10·06 | 74·69 |
| 3·272 | 171·902 | −0·145 | 44·11 | ·35 | 41·27 | 10·24 | 74·72 |
| 3·268 | 171·915 | −0·147 | 43·84 | ·36 | 41·02 | 10·40 | 74·75 |
| 3·259 | 171·942 | −0·148 | 43·56 | ·37 | 40·76 | 10·55 | 74·77 |
| 3·246 | 171·982 | −0·149 | 43·29 | ·37 | 40·51 | 10·69 | 74·79 |
| 3·228 | 172·035 | −0·150 | 43·02 | ·38 | 40·25 | 10·81 | 74·81 |
| 3·206 | 172·101 | −0·150 | 42·75 | ·38 | 39·99 | 10·92 | 74·83 |
| 3·179 | 172·181 | −0·150 | 42·48 | ·39 | 39·74 | 11·02 | 74·84 |
| 3·148 | 172·273 | −0·149 | 42·21 | ·39 | 39·48 | 11·10 | 74·84 |
| 3·113 | 172·376 | −0·148 | 41·94 | ·39 | 39·23 | 11·17 | 74·83 |
| 3·074 | 172·494 | −0·147 | 41·67 | ·40 | 38·98 | 11·23 | 74·82 |
| 3·031 | 172·623 | −0·145 | 41·40 | ·40 | 38·73 | 11·28 | 74·81 |
| 2·983 | 172·765 | −0·143 | 41·14 | ·40 | 38·49 | 11·32 | 74·80 |
| 2·931 | 172·919 | −0·140 | 40·88 | ·40 | 38·25 | 11·34 | 74·78 |
| 2·876 | 173·085 | −0·137 | 40·62 | ·40 | 38·01 | 11·35 | 74·75 |
| 2·817 | 173·263 | −0·133 | 40·36 | ·40 | 37·77 | 11·35 | 74·72 |
| 2·754 | 173·451 | −0·129 | 40·11 | ·39 | 37·54 | 11·34 | 74·69 |
| 2·688 | 173·652 | −0·125 | 39·86 | ·39 | 37·30 | 11·31 | 74·66 |
| 2·618 | 173·864 | −0·121 | 39·62 | ·38 | 37·07 | 11·28 | 74·62 |
| 2·545 | 174·087 | −0·116 | 39·38 | ·38 | 36·84 | 11·23 | 74·58 |

| Greenwich Noon. | | Longitude of ℣'s Central Meridian. 877°·90 I. | 870°·27 II. | Corr. for Phase. | Light-time. | A—O. | B. |
|---|---|---|---|---|---|---|---|
| 1902. | | ° | ° | ° | m | ″ | ″ |
| Oct. | 1 | 307·99 | 229·67 | −0·42 | 37·213 | | |
| | 3 | 263·67 | 170·09 | ·44 | 37·436 | | |
| | 5 | 219·33 | 110·49 | ·46 | 37·665 | | |
| | 7 | 174·98 | 50·88 | ·47 | 37·898 | | |
| | 9 | 130·61 | 351·25 | ·48 | 38·135 | 182·486 | +0·136 |
| | 11 | 86·22 | 291·60 | ·50 | 38·375 | | |
| | 13 | 41·81 | 231·93 | ·51 | 38·616 | | |
| | 15 | 357·39 | 172·25 | ·52 | 38·864 | | |
| | 17 | 312·97 | 112·58 | ·53 | 39·114 | | |
| | 19 | 268·53 | 52·88 | ·54 | 39·364 | 183·367 | +0·183 |
| | 21 | 224·08 | 353·17 | ·55 | 39·617 | | |
| | 23 | 179·61 | 293·45 | ·55 | 39·870 | | |
| | 25 | 135·12 | 233·70 | ·55 | 40·125 | | |
| | 27 | 90·61 | 173·94 | ·56 | 40·382 | | |
| | 29 | 46·10 | 114·16 | ·56 | 40·639 | 184·249 | +0·230 |
| | 31 | 1·58 | 54·38 | ·56 | 40·897 | | |
| Nov. | 2 | 317·05 | 354·59 | ·56 | 41·155 | | |
| | 4 | 272·50 | 294·78 | ·56 | 41·413 | | |
| | 6 | 227·94 | 234·96 | ·56 | 41·671 | | |
| | 8 | 183·37 | 175·13 | ·55 | 41·928 | 185·131 | +0·275 |
| | 10 | 138·79 | 115·29 | ·55 | 42·185 | | |
| | 12 | 94·20 | 55·44 | ·54 | 42·440 | | |
| | 14 | 49·60 | 355·58 | ·54 | 42·694 | | |
| | 16 | 4·99 | 295·72 | ·53 | 42·947 | | |
| | 18 | 320·38 | 235·85 | ·52 | 43·198 | 186·014 | +0·322 |
| | 20 | 275·76 | 175·97 | ·51 | 43·447 | | |
| | 22 | 231·12 | 116·07 | ·50 | 43·693 | | |
| | 24 | 186·48 | 56·17 | ·49 | 43·939 | | |
| | 26 | 141·83 | 356·26 | ·48 | 44·180 | | |
| | 28 | 97·18 | 296·35 | ·47 | 44·419 | 186·898 | +0·370 |
| | 30 | 52·52 | 236·43 | ·46 | 44·654 | | |
| Dec. | 2 | 7·85 | 176·50 | ·44 | 44·887 | | |
| | 4 | 323·17 | 116·57 | ·43 | 45·116 | | |
| | 6 | 278·49 | 56·63 | ·41 | 45·342 | | |
| | 8 | 233·81 | 356·69 | ·40 | 45·564 | 187·784 | +0·417 |
| | 10 | 189·12 | 296·74 | ·38 | 45·781 | | |
| | 12 | 144·42 | 236·79 | ·37 | 45·995 | | |
| | 14 | 99·72 | 176·83 | −0·35 | 46·205 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 28 | 340·127 | 182·079 | +0·125 | 34·95 | ·15 | 32 |
| 30 | 340·012 | 182·497 | +0·140 | 34·82 | ·14 | 32 |
| 1903. Jan. 1 | 339·897 | 182·921 | +0·155 | 34·70 | ·13 | 32 |
| 3 | 339·781 | 183·350 | +0·170 | 34·59 | ·12 | 32 |
| 5 | 339·665 | 183·781 | +0·186 | 34·48 | ·11 | 32 |
| 7 | 339·550 | 184·219 | +0·202 | 34·38 | ·10 | 32 |
| 9 | 339·435 | 184·659 | +0·219 | 34·28 | ·09 | 32 |
| 11 | 339·319 | 185·104 | +0·236 | 34·19 | ·08 | 31 |
| 13 | 339·204 | 185·552 | +0·253 | 34·10 | ·08 | 31 |
| 15 | 339·088 | 186·003 | +0·271 | 34·01 | ·07 | 31 |
| 17 | 338·972 | 186·459 | +0·289 | 33·93 | 0·06 | 31 |

The following is a list of the Greenwic the Zero meridians of the two adopted syst of the illuminated disc :—

*System I.*

| 1902. | d | h | m | 1902. | d | h | m | 1902. | d | h | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb. | 21 | 5 | 10·38 | Feb. | 27 | 18 | 40·19 | Mar. | 6 | 8 | |
| | | 15 | 1·00 | | 28 | 4 | 30·80 | | | 18 | |
| | 22 | 0 | 51·62 | | | 14 | 21·41 | | 7 | 3 | 51 |
| | | 10 | 42·24 | Mar. | 1 | 0 | 12·02 | | | 13 | 41 |
| | | 20 | 32·85 | | | 10 | 2·63 | | | 23 | 32 |
| | 23 | 6 | 23·47 | | | 19 | 53·24 | | 8 | 9 | 22 |
| | | 16 | 14·08 | | 2 | 5 | 43·85 | | | 19 | 13 |
| | 24 | 2 | 4·69 | | | 15 | 34·45 | | 9 | 5 | 4 |
| | | 11 | 55·30 | | 3 | 1 | 25·05 | | | 14 | 54 |
| | | 21 | 45·91 | | | | | | | | |

| Greenwich Noon. | Longitude of ♃'s Central Meridian. 877°·90 I. | 870°·27 II. | Corr. for Phase. | Light-time. | A−O. | B. |
|---|---|---|---|---|---|---|
| 1902. | ° | ° | ° | m | • | • |
| Dec. 16 | 55·02 | 116·87 | −0·34 | 46·410 | | |
| 18 | 10·31 | 56·90 | ·32 | 46·610 | 188·671 | +0·465 |
| 20 | 325·60 | 356·93 | ·31 | 46·804 | | |
| 22 | 280·89 | 296·96 | ·29 | 46·995 | | |
| 24 | 236·18 | 236·99 | ·28 | 47·180 | | |
| 26 | 191·46 | 177·01 | ·26 | 47·360 | | |
| 28 | 146·74 | 117·03 | ·25 | 47·534 | 189·559 | +0·512 |
| 30 | 102·02 | 57·05 | ·23 | 47·705 | | |
| 1903. | | | | | | |
| Jan. 1 | 57·30 | 357·06 | ·21 | 47·868 | | |
| 3 | 12·57 | 297·08 | ·20 | 48·026 | | |
| 5 | 327·84 | 237·09 | ·18 | 48·178 | | |
| 7 | 283·12 | 177·11 | ·17 | 48·324 | 190·448 | +0·559 |
| 9 | 238·40 | 117·12 | ·16 | 48·464 | | |
| 11 | 193·67 | 57·14 | ·14 | 48·598 | | |
| 13 | 148·95 | 357·15 | ·13 | 48·726 | | |
| 15 | 104·22 | 297·17 | ·12 | 48·848 | | |
| 17 | 59·49 | 237·19 | −0·10 | 48·963 | 191·338 | +0·607 |

*System I.*

| 1902. | d | h | m | 1902. | d | h | m | 1902. | d | h | m | 1902. | d | h | m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mar. | 19 | 11 | 8·79 | Mar. | 26 | 20 | 19·17 | Apr. | 3 | 5 | 29·35 | Apr. | 10 | 14 | 39·33 |
| | | 20 | 59·37 | | 27 | 6 | 9·74 | | | 15 | 19·91 | | 11 | 0 | 29·88 |
| | 20 | 6 | 49·96 | | | 16 | 0·31 | | 4 | 1 | 10·47 | | | 10 | 20·42 |
| | | 16 | 40·54 | | 28 | 1 | 50·88 | | | 11 | 1·03 | | | 20 | 10·96 |
| | 21 | 2 | 31·12 | | | 11 | 41·45 | | | 20 | 51·60 | | 12 | 6 | 1·51 |
| | | 12 | 21·70 | | | 21 | 32·03 | | 5 | 6 | 42·16 | | | 15 | 52·06 |
| | | 22 | 12·28 | | 29 | 7 | 22·59 | | | 16 | 32·72 | | 13 | 1 | 42·60 |
| | 22 | 8 | 2·86 | | | 17 | 13·15 | | 6 | 2 | 23·29 | | | 11 | 33·14 |
| | | 17 | 53·44 | | 30 | 3 | 3·72 | | | 12 | 13·85 | | | 21 | 23·68 |
| | 23 | 3 | 44·01 | | | 12 | 54·28 | | | 22 | 4·42 | | 14 | 7 | 14·23 |
| | | 13 | 34·59 | | | 22 | 44·84 | | 7 | 7 | 54·98 | | | 17 | 4·77 |
| | | 23 | 25·16 | | 31 | 8 | 35·40 | | | 17 | 45·53 | | 15 | 2 | 55·31 |
| | 24 | 9 | 15·73 | | | 18 | 25·96 | | 8 | 3 | 36·07 | | | 12 | 45·85 |
| | | 19 | 6·31 | Apr. | 1 | 4 | 16·53 | | | 13 | 26·62 | | | 22 | 36·40 |
| | 25 | 4 | 56·88 | | | 14 | 7·09 | | | 23 | 17·16 | | 16 | 8 | 26·94 |
| | | 14 | 47·45 | | | 23 | 57·65 | | 9 | 9 | 7·70 | | | 18 | 17·48 |
| | 26 | 0 | 38·02 | | 2 | 9 | 48·22 | | | 18 | 58·25 | | 17 | 4 | 8·02 |
| | | 10 | 28·60 | | | 19 | 38·78 | | 10 | 4 | 48·79 | | | 13 | 58·56 |

*System I.*

| m | 1902. | d | h | m | 1902. | d | h | m | 1902. | d | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ·09 | May | 3 | 13 | 49·01 | May | 19 | 3 | 47·96 | June | 3 | 1 |
| ·62 | | | 23 | 39·52 | | | 13 | 38·44 | | 4 | |
| ·16 | | 4 | 9 | 30·03 | | | 23 | 28·93 | | | 1 |
| ·69 | | | 19 | 20·54 | | 20 | 9 | 19·41 | | | 2 |
| ·22 | | 5 | 5 | 11·05 | | | 19 | 9·89 | | 5 | |
| ·75 | | | 15 | 1·56 | | 21 | 5 | 0·37 | | | 1 |
| ·29 | | 6 | 0 | 52·07 | | | 14 | 50·85 | | 6 | |
| ·82 | | | 10 | 42·58 | | 22 | 0 | 41·33 | | | 1 |
| ·35 | | | 20 | 33·09 | | | 10 | 31·81 | | 7 | |
| ·88 | | 7 | 6 | 23·60 | | | 20 | 22·29 | | | 1 |
| ·41 | | | 16 | 14·11 | | 23 | 6 | 12·77 | | | 2 |
| ·94 | | 8 | 2 | 4·61 | | | 16 | 3·24 | | 8 | |
| ·47 | | | 11 | 55·11 | | 24 | 1 | 53·72 | | | 1 |
| ·01 | | | 21 | 45·61 | | | 11 | 44·20 | | 9 | |
| ·54 | | 9 | 7 | 36·11 | | | 21 | 34·68 | | | 1 |
| ·07 | | | 17 | 26·61 | | 25 | 7 | 25·15 | | | 2 |
| ·60 | | 10 | 3 | 17·11 | | | 17 | 15·63 | | 10 | |
| ·14 | | | 13 | 7·61 | | 26 | 3 | 6·11 | | | 1 |
| ·67 | | | 22 | 58·11 | | | 12 | 56·59 | | 11 | |
| ·20 | | 11 | 8 | 48·61 | | | 22 | 47·07 | | | 1 |

*System I.*

| 1902. | d | h | m | 1902. | d | h | m | 1902. | d | h | m | 1902. | d | h | m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| June | 19 | 7 | 42·99 | July | 4 | 21 | 39·17 | July | 20 | 11 | 34·82 | Aug. | 5 | 1 | 30·35 |
| | | 17 | 33·42 | | 5 | 7 | 29·59 | | | 21 | 25·23 | | | 11 | 20·76 |
| | 20 | 3 | 23·85 | | | 17 | 20·01 | | 21 | 7 | 15·64 | | | 21 | 11·17 |
| | | 13 | 14·28 | | 6 | 3 | 10·42 | | | 17 | 6·05 | | 6 | 7 | 1·59 |
| | | 23 | 4·72 | | | 13 | 0·84 | | 22 | 2 | 56·46 | | | 16 | 52·00 |
| | 21 | 8 | 55·15 | | | 22 | 51·25 | | | 12 | 46·87 | | 7 | 2 | 42·41 |
| | | 18 | 45·58 | | 7 | 8 | 41·67 | | | 22 | 37·28 | | | 12 | 32·83 |
| | 22 | 4 | 36·01 | | | 18 | 32·08 | | 23 | 8 | 27·69 | | | 22 | 23·24 |
| | | 14 | 26·44 | | 8 | 4 | 22·50 | | | 18 | 18·10 | | 8 | 8 | 13·66 |
| | 23 | 0 | 16 87 | | | 14 | 12·91 | | 24 | 4 | 8·51 | | | 18 | 4·07 |
| | | 10 | 7·30 | | 9 | 0 | 3·33 | | | 13 | 58·92 | | 9 | 3 | 54·49 |
| | | 19 | 57·73 | | | 9 | 53·74 | | | 23 | 49·33 | | | 13 | 44·91 |
| | 24 | 5 | 48·16 | | | 19 | 44·16 | | 25 | 9 | 39·74 | | | 23 | 35·33 |
| | | 15 | 38·59 | | 10 | 5 | 34·57 | | | 19 | 30·14 | | 10 | 9 | 25·75 |
| | 25 | 1 | 29·02 | | | 15 | 24·98 | | 26 | 5 | 20·54 | | | 19 | 16·17 |
| | | 11 | 19·45 | | 11 | 1 | 15·39 | | | 15 | 10·94 | | 11 | 5 | 6·59 |
| | | 21 | 9·88 | | | 11 | 5 80 | | 27 | 1 | 1·34 | | | 14 | 57·01 |
| | 26 | 7 | 0·31 | | | 20 | 56·21 | | | 10 | 51·74 | | 12 | 0 | 47·43 |
| | | 16 | 50·74 | | 12 | 6 | 46·62 | | | 20 | 42·15 | | | 10 | 37·86 |
| | 27 | 2 | 41·17 | | | 16 | 37·03 | | 28 | 6 | 32·56 | | | 20 | 28·28 |
| | | 12 | 31·60 | | 13 | 2 | 27·44 | | | 16 | 22·97 | | 13 | 6 | 18·70 |
| | | 22 | 22·03 | | | 12 | 17·85 | | 29 | 2 | 13·38 | | | 16 | 9·13 |
| | 28 | 8 | 12·45 | | | 22 | 8·26 | | | 12 | 3·79 | | 14 | 1 | 59·55 |
| | | 18 | 2·87 | | 14 | 7 | 58·67 | | | 21 | 54·20 | | | 11 | 49 97 |
| | 29 | 3 | 53·29 | | | 17 | 49·08 | | 30 | 7 | 44·61 | | | 21 | 40·40 |
| | | 13 | 43·71 | | 15 | 3 | 39·49 | | | 17 | 35·02 | | 15 | 7 | 30·82 |
| | | 23 | 34·13 | | | 13 | 29·90 | | 31 | 3 | 25·43 | | | 17 | 21·25 |
| | 30 | 9 | 24·55 | | | 23 | 20·31 | | | 13 | 15·84 | | 16 | 3 | 11·68 |
| | | 19 | 14·97 | | 16 | 9 | 10·72 | | | 23 | 6·25 | | | 13 | 2·11 |
| July | 1 | 5 | 5·39 | | | 19 | 1·13 | Aug. | 1 | 8 | 56·66 | | | 22 | 52·54 |
| | | 14 | 55·81 | | 17 | 4 | 51·54 | | | 18 | 47·07 | | 17 | 8 | 42·97 |
| | 2 | 0 | 46·23 | | | 14 | 41·95 | | 2 | 4 | 37·48 | | | 18 | 33·40 |
| | | 10 | 36·65 | | 18 | 0 | 32·36 | | | 14 | 27·89 | | 18 | 4 | 23·84 |
| | | 20 | 27·07 | | | 10 | 22·77 | | 3 | 0 | 18·30 | | | 14 | 14·27 |
| | 3 | 6 | 17·49 | | | 20 | 13·18 | | | 10 | 8·71 | | 19 | 0 | 4·71 |
| | | 16 | 7·91 | | 19 | 6 | 3·59 | | | 19 | 59·12 | | | 9 | 55·14 |
| | 4 | 1 | 58·33 | | | 15 | 54·00 | | 4 | 5 | 49·53 | | | 19 | 45·58 |
| | | 11 | 48·75 | | 20 | 1 | 44·41 | | | 15 | 39·94 | | 20 | 5 | 36·02 |

*System I.*

| | 1902. | d | h | m | 1902. | d | h | m | 1902. | d | h | m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 | Sept. | 5 | 5 | 23·84 | Sept. | 20 | 19 | 22·71 | Oct. | 6 | 9 | 23·16 |
| 90 | | | 15 | 14·32 | | 21 | 5 | 13·23 | | | 19 | 13·72 |
| 34 | | 6 | 1 | 4·80 | | | 15 | 3·75 | | 7 | 5 | 4·28 |
| 78 | | | 10 | 55·28 | | 22 | 0 | 54·28 | | | 14 | 54·84 |
| 23 | | | 20 | 45·76 | | | 10 | 44·80 | | 8 | 0 | 45·40 |
| 67 | | 7 | 6 | 36·24 | | | 20 | 35·32 | | | 10 | 35·96 |
| 11 | | | 16 | 26·72 | | 23 | 6 | 25·85 | | | 20 | 26·52 |
| 56 | | 8 | 2 | 17·20 | | | 16 | 16·37 | | 9 | 6 | 17·09 |
| 00 | | | 12 | 7·68 | | 24 | 2 | 6·89 | | | 16 | 7·66 |
| 45 | | | 21 | 58·16 | | | 11 | 57·42 | | 10 | 1 | 58·23 |
| 89 | | 9 | 7 | 48·65 | | | 21 | 47·95 | | | 11 | 48·80 |
| 34 | | | 17 | 39·14 | | 25 | 7 | 38·48 | | | 21 | 39·37 |
| 79 | | 10 | 3 | 29·63 | | | 17 | 29·01 | | 11 | 7 | 29·94 |
| 24 | | | 13 | 20·13 | | 26 | 3 | 19·55 | | | 17 | 20·52 |
| 69 | | | 23 | 10·62 | | | 13 | 10·08 | | 12 | 3 | 11·09 |
| 15 | | 11 | 9 | 1·11 | | | 23 | 0·61 | | | 13 | 1·66 |
| 60 | | | 18 | 51·61 | | 27 | 8 | 51·15 | | | 22 | 52·23 |
| 06 | | 12 | 4 | 42·10 | | | 18 | 41·69 | | 13 | 8 | 42·81 |
| 51 | | | 14 | 32·60 | | 28 | 4 | 32·22 | | | 18 | 33·38 |
| 97 | | 13 | 0 | 23·09 | | | 14 | 22·76 | | 14 | 4 | 23·96 |
| 43 | | | 10 | 13·59 | | 29 | 0 | 13·30 | | | 14 | 14·53 |

*System I.*

| 1902. | d | h | m | 1902. | d | h | m | 1902. | d | h | m | 1902. | d | h | m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. | 21 | 23 | 25·08 | Nov. | 6 | 13 | 28·19 | Nov. | 22 | 3 | 32·28 | Dec. | 7 | 17 | 37·04 |
| | 22 | 9 | 15·68 | | | 23 | 18·81 | | | 13 | 22·92 | | 8 | 3 | 27·70 |
| | | 19 | 6·27 | | 7 | 9 | 9·43 | | | 23 | 13·57 | | | 13 | 18·36 |
| | 23 | 4 | 56·86 | | | 19 | 0·05 | | 23 | 9 | 4·21 | | | 23 | 9·02 |
| | | 14 | 47·46 | | 8 | 4 | 50·68 | | | 18 | 54·85 | | 9 | 8 | 59·68 |
| | 24 | 0 | 38·06 | | | 14 | 41·31 | | 24 | 4 | 45·50 | | | 18 | 50·34 |
| | | 10 | 28·66 | | 9 | 0 | 31·94 | | | 14 | 36·14 | | 10 | 4 | 41·00 |
| | | 20 | 19·26 | | | 10 | 22·57 | | 25 | 0 | 26·79 | | | 14 | 31·66 |
| | 25 | 6 | 9·86 | | | 20 | 13·20 | | | 10 | 17·44 | | 11 | 0 | 22·32 |
| | | 16 | 0·47 | | 10 | 6 | 3·83 | | | 20 | 8·09 | | | 10 | 12·99 |
| | 26 | 1 | 51·07 | | | 15 | 54·46 | | 26 | 5 | 58·73 | | | 20 | 3·65 |
| | | 11 | 41·68 | | 11 | 1 | 45·09 | | | 15 | 49·38 | | 12 | 5 | 54·31 |
| | | 21 | 32·28 | | | 11 | 35·72 | | 27 | 1 | 40·03 | | | 15 | 44·98 |
| | 27 | 7 | 22·88 | | | 21 | 26·35 | | | 11 | 30·68 | | 13 | 1 | 35·64 |
| | | 17 | 13·48 | | 12 | 7 | 16·99 | | | 21 | 21·33 | | | 11 | 26·30 |
| | 28 | 3 | 4·09 | | | 17 | 7·62 | | 28 | 7 | 11·98 | | | 21 | 16·97 |
| | | 12 | 54·69 | | 13 | 2 | 58·25 | | | 17 | 2·63 | | 14 | 7 | 7·63 |
| | | 22 | 45·29 | | | 12 | 48·88 | | 29 | 2 | 53·28 | | | 16 | 58·29 |
| | 29 | 8 | 35·90 | | | 22 | 39·51 | | | 12 | 43·94 | | 15 | 2 | 48·96 |
| | | 18 | 26·51 | | 14 | 8 | 30·14 | | | 22 | 34·59 | | | 12 | 39·62 |
| | 30 | 4 | 17·12 | | | 18 | 20·78 | | 30 | 8 | 25·24 | | | 22 | 30·29 |
| | | 14 | 7·73 | | 15 | 4 | 11·41 | | | 18 | 15·90 | | 16 | 8 | 20·95 |
| | | 23 | 58·34 | | | 14 | 2·05 | Dec. | 1 | 4 | 6·55 | | | 18 | 11·62 |
| | 31 | 9 | 48·96 | | | 23 | 52·68 | | | 13 | 57·20 | | 17 | 4 | 2·28 |
| | | 19 | 39·57 | | 16 | 9 | 43·32 | | | 23 | 47·86 | | | 13 | 52·95 |
| Nov. | 1 | 5 | 30·18 | | | 19 | 33·95 | | 2 | 9 | 38·51 | | | 23 | 43·61 |
| | | 15 | 20·79 | | 17 | 5 | 24·58 | | | 19 | 29·17 | | 18 | 9 | 34·28 |
| | 2 | 1 | 11·41 | | | 15 | 15·22 | | 3 | 5 | 19·82 | | | 19 | 24·94 |
| | | 11 | 2·02 | | 18 | 1 | 5·86 | | | 15 | 10·48 | | 19 | 5 | 15·61 |
| | | 20 | 52·64 | | | 10 | 56·50 | | 4 | 1 | 1·13 | | | 15 | 6·27 |
| | 3 | 6 | 43·25 | | | 20 | 47·14 | | | 10 | 51·79 | | 20 | 0 | 56·94 |
| | | 16 | 33·86 | | 19 | 6 | 37·78 | | | 20 | 42·45 | | | 10 | 47·60 |
| | 4 | 2 | 24·48 | | | 16 | 28·42 | | 5 | 6 | 33·10 | | | 20 | 38·27 |
| | | 12 | 15·09 | | 20 | 2 | 19·07 | | | 16 | 23·76 | | 21 | 6 | 28·93 |
| | | 22 | 5·71 | | | 12 | 9·71 | | 6 | 2 | 14·41 | | | 16 | 19·60 |
| | 5 | 7 | 56·33 | | | 22 | 0·35 | | | 12 | 5·07 | | 22 | 2 | 10·27 |
| | | 17 | 46·95 | | 21 | 7 | 50·99 | | | 21 | 55·73 | | | 12 | 0·94 |
| | | 3 | 37·57 | | | 17 | 41·64 | | 7 | 7 | 46·38 | | | 21 | 51·60 |

*System I.*

| m | 1902. | d | h | m | 1903. | d | h | m | 1903. | d | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2·27 | Dec. | 29 | 21 | 12·99 | Jan. | 5 | 0 | 53·06 | Jan. | 11 | 1 |
| 2·94 | | 30 | 7 | 3·66 | | | 10 | 43·73 | | 12 | |
| 3·61 | | | 16 | 54·33 | | | 20 | 34·40 | | | 1 |
| 4·28 | | 31 | 2 | 45·00 | | 6 | 6 | 25·07 | | | 1 |
| 4·95 | | | 12 | 35·67 | | | 16 | 15·74 | | 13 | |
| 5·62 | | | 22 | 26·34 | | 7 | 2 | 6·42 | | | 1 |
| 6·29 | 1903. Jan. | 1 | 8 | 17·01 | | | 11 | 57·09 | | 14 | |
| 6·96 | | | 18 | 7·68 | | | 21 | 47·76 | | | 1 |
| 7·63 | | 2 | 3 | 58·35 | | 8 | 7 | 38·43 | | | 2 |
| 8·30 | | | 13 | 49·03 | | | 17 | 29 10 | | 15 | |
| 8·97 | | | 23 | 39·70 | | 9 | 3 | 19·78 | | | 1 |
| 9·64 | | 3 | 9 | 30·37 | | | 13 | 10·45 | | 16 | |
| 0·31 | | | 19 | 21·04 | | | 23 | 1·12 | | | 1 |
| 0·98 | | 4 | 5 | 11·71 | | 10 | 8 | 51·79 | | | 2 |
| 1·65 | | | 15 | 2·39 | | | 18 | 42·46 | | 17 | |
| 2·32 | | | | | | 11 | 4 | 33·14 | | | |

*System II.*

| m | 1902. | d | h | m | 1902. | d | h | m | 1902. | d | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 22·48 | Mar. | 1 | 6 | 58·30 | Mar. | 9 | 13 | 33·91 | Mar. | 17 | 2 |
| 8·27 | | | 16 | 54·09 | | | 23 | 29·69 | | 18 | |

*System II.*

| 1902. | d | h | m |
|---|---|---|---|
| Mar. | 26 | 2 | 44·43 |
| | | 12 | 40·17 |
| | | 22 | 35·92 |
| | 27 | 8 | 31·67 |
| | | 18 | 27·42 |
| | 28 | 4 | 23·17 |
| | | 14 | 18·91 |
| | 29 | 0 | 14·66 |
| | | 10 | 10·41 |
| | | 20 | 6·16 |
| | 30 | 6 | 1·90 |
| | | 15 | 57·65 |
| | 31 | 1 | 53·39 |
| | | 11 | 49·14 |
| | | 21 | 44·88 |
| Apr. | 1 | 7 | 40·63 |
| | | 17 | 36·38 |
| | 2 | 3 | 32·12 |
| | | 13 | 27·86 |
| | | 23 | 23·60 |
| | 3 | 9 | 19·33 |
| | | 19 | 15·07 |
| | 4 | 5 | 10·80 |
| | | 15 | 6·54 |
| | 5 | 1 | 2·27 |
| | | 10 | 58·01 |
| | | 20 | 53·74 |
| | 6 | 6 | 49·48 |
| | | 16 | 45·21 |
| | 7 | 2 | 40·95 |
| | | 12 | 36·68 |
| | | 22 | 32·42 |
| | 8 | 8 | 28·15 |
| | | 18 | 23·89 |
| | 9 | 4 | 19·62 |
| | | 14 | 15·35 |
| | 10 | 0 | 11·08 |
| | | 10 | 6·80 |

| 1902. | d | h | m |
|---|---|---|---|
| Apr. | 10 | 20 | 2·53 |
| | 11 | 5 | 58 26 |
| | | 15 | 53·99 |
| | 12 | 1 | 49·71 |
| | | 11 | 45·43 |
| | | 21 | 41·15 |
| | 13 | 7 | 36·87 |
| | | 17 | 32·58 |
| | 14 | 3 | 28·30 |
| | | 13 | 24·02 |
| | | 23 | 19·74 |
| | 15 | 9 | 15·45 |
| | | 19 | 11·17 |
| | 16 | 5 | 6·88 |
| | | 15 | 2·60 |
| | 17 | 0 | 58·32 |
| | | 10 | 54·03 |
| | | 20 | 49·75 |
| | 18 | 6 | 45·46 |
| | | 16 | 41·18 |
| | 19 | 2 | 36·89 |
| | | 12 | 32·61 |
| | | 22 | 28·32 |
| | 20 | 8 | 24·03 |
| | | 18 | 19·75 |
| | 21 | 4 | 15·46 |
| | | 14 | 11·17 |
| | 22 | 0 | 6·88 |
| | | 10 | 2·59 |
| | | 19 | 58·29 |
| | 23 | 5 | 54·00 |
| | | 15 | 49·70 |
| | 24 | 1 | 45·41 |
| | | 11 | 41·11 |
| | | 21 | 36·82 |
| | 25 | 7 | 32 52 |
| | | 17 | 28·23 |
| | 26 | 3 | 23·93 |

| 1902. | d | h | m |
|---|---|---|---|
| Apr. | 26 | 13 | 19·63 |
| | | 23 | 15·33 |
| | 27 | 9 | 11·03 |
| | | 19 | 6·73 |
| | 28 | 5 | 2·43 |
| | | 14 | 58·13 |
| | 29 | 0 | 53·83 |
| | | 10 | 49·53 |
| | | 20 | 45·23 |
| | 30 | 6 | 40·93 |
| | | 16 | 36·62 |
| May | 1 | 2 | 32·32 |
| | | 12 | 28·01 |
| | | 22 | 23·71 |
| | 2 | 8 | 19·40 |
| | | 18 | 15·09 |
| | 3 | 4 | 10·78 |
| | | 14 | 6·47 |
| | 4 | 0 | 2·15 |
| | | 9 | 57·84 |
| | | 19 | 53·53 |
| | 5 | 5 | 49·21 |
| | | 15 | 44·89 |
| | 6 | 1 | 40·58 |
| | | 11 | 36·26 |
| | | 21 | 31·95 |
| | 7 | 7 | 27 63 |
| | | 17 | 23·32 |
| | 8 | 3 | 19 00 |
| | | 13 | 14·69 |
| | | 23 | 10·38 |
| | 9 | 9 | 6·07 |
| | | 19 | 1·75 |
| | 10 | 4 | 57·43 |
| | | 14 | 53·11 |
| | 11 | 0 | 48·79 |
| | | 10 | 44·46 |
| | | 20 | 40·14 |

| 1902. | d | h | m |
|---|---|---|---|
| May | 12 | 6 | 35·81 |
| | | 16 | 31·48 |
| | 13 | 2 | 27·15 |
| | | 12 | 22·82 |
| | | 22 | 18·48 |
| | 14 | 8 | 14·15 |
| | | 18 | 9·82 |
| | 15 | 4 | 5·48 |
| | | 14 | 1·15 |
| | | 23 | 56·82 |
| | 16 | 9 | 52·48 |
| | | 19 | 48·15 |
| | 17 | 5 | 43·82 |
| | | 15 | 39·48 |
| | 18 | 1 | 35·15 |
| | | 11 | 30·82 |
| | | 21 | 26·48 |
| | 19 | 7 | 22·15 |
| | | 17 | 17·81 |
| | 20 | 3 | 13·48 |
| | | 13 | 9·14 |
| | | 23 | 4·80 |
| | 21 | 9 | 0·47 |
| | | 18 | 56·13 |
| | 22 | 4 | 51·79 |
| | | 14 | 47·45 |
| | 23 | 0 | 43·10 |
| | | 10 | 38 76 |
| | | 20 | 34·41 |
| | 24 | 6 | 30·07 |
| | | 16 | 25·72 |
| | 25 | 2 | 21·38 |
| | | 12 | 17·03 |
| | | 22 | 12·68 |
| | 26 | 8 | 8·33 |
| | | 18 | 3·98 |
| | 27 | 3 | 59·63 |
| | | 13 | 55·28 |

*System II.*

| | 1902. | d | h | m | 1902. | d | h | m | 1902. | d | h |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 93 | June | 12 | 17 | 5·08 | June | 28 | 10 | 18·31 | July | 14 | 3 |
| 58 | | 13 | 3 | 0·70 | | | 20 | 13·91 | | | 13 |
| 22 | | | 12 | 56·32 | | 29 | 6 | 9·51 | | | 23 |
| 87 | | | 22 | 51·94 | | | 16 | 5·11 | | 15 | 9 |
| 51 | | 14 | 8 | 47 56 | | 30 | 2 | 0·71 | | | 19 |
| 16 | | | 18 | 43·18 | | | 11 | 56·31 | | 16 | 5 |
| 80 | | 15 | 4 | 38·80 | | | 21 | 51 91 | | | 15 |
| 45 | | | 14 | 34·42 | July | 1 | 7 | 47·51 | | 17 | 0 |
| 09 | | 16 | 0 | 30·04 | | | 17 | 43·11 | | | 10 |
| 74 | | | 10 | 25·66 | | 2 | 3 | 38·70 | | | 20 |
| 38 | | | 20 | 21·27 | | | 13 | 34·30 | | 18 | 6 |
| 02 | | 17 | 6 | 16·89 | | | 23 | 29 89 | | | 16 |
| 66 | | | 16 | 12·50 | | 3 | 9 | 25 49 | | 19 | 2 |
| 30 | | 18 | 2 | 8·12 | | | 19 | 21·08 | | | 12 |
| 93 | | | 12 | 3·73 | | 4 | 5 | 16·68 | | | 22 |
| 57 | | | 21 | 59 35 | | | 15 | 12·27 | | 20 | 8 |
| 21 | | 19 | 7 | 54·96 | | 5 | 1 | 7·87 | | | 18 |
| 84 | | | 17 | 50·58 | | | 11 | 3·46 | | 21 | 4 |
| 48 | | 20 | 3 | 46·19 | | | 20 | 59·06 | | | 14 |
| 11 | | | 13 | 41·81 | | 6 | 6 | 54·65 | | 22 | 0 |

*System II.*

| 1902. | d | h | m | 1902. | d | h | m | 1902. | d | h | m | 1902. | d | h | m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July | 29 | 20 | 43·04 | Aug. | 14 | 13 | 55·53 | Aug. | 30 | 7 | 9·02 | Sept. | 15 | 0 | 24·02 |
| | 30 | 6 | 38·62 | | | 23 | 51·13 | | | 17 | 4·66 | | | 10 | 19·70 |
| | | 16 | 34·20 | | 15 | 9 | 46·74 | | 31 | 3 | 0·30 | | | 20 | 15·38 |
| | 31 | 2 | 29·79 | | | 19 | 42·34 | | | 12 | 55·95 | | 16 | 6 | 11·07 |
| | | 12 | 25·37 | | 16 | 5 | 37·94 | | | 22 | 51·59 | | | 16 | 6·75 |
| | | 22 | 20·95 | | | 15 | 33·54 | Sept. | 1 | 8 | 47·24 | | 17 | 2 | 2·44 |
| Aug. | 1 | 8 | 16·54 | | 17 | 1 | 29·14 | | | 18 | 42·88 | | | 11 | 58·12 |
| | | 18 | 12·12 | | | 11 | 24·75 | | 2 | 4 | 38·53 | | | 21 | 53 81 |
| | 2 | 4 | 7·70 | | | 21 | 20·35 | | | 14 | 34·17 | | 18 | 7 | 49·49 |
| | | 14 | 3·29 | | 18 | 7 | 15·95 | | 3 | 0 | 29·82 | | | 17 | 45·18 |
| | | 23 | 58·87 | | | 17 | 11·55 | | | 10 | 25·46 | | 19 | 3 | 40 87 |
| | 3 | 9 | 54·46 | | 19 | 3 | 7·16 | | | 20 | 21·11 | | | 13 | 36·56 |
| | | 19 | 50·05 | | | 13 | 2·78 | | 4 | 6 | 16·75 | | | 23 | 32·25 |
| | 4 | 5 | 45·63 | | | 22 | 58·39 | | | 16 | 12·41 | | 20 | 9 | 27·95 |
| | | 15 | 41·22 | | 20 | 8 | 54·01 | | 5 | 2 | 8·06 | | | 19 | 23·64 |
| | 5 | 1 | 36·81 | | | 18 | 49·63 | | | 12 | 3·72 | | 21 | 5 | 19 34 |
| | | 11 | 32·39 | | 21 | 4 | 45 25 | | | 21 | 59·37 | | | 15 | 15·04 |
| | | 21 | 27·98 | | | 14 | 40·87 | | 6 | 7 | 55·03 | | 22 | 1 | 10·73 |
| | 6 | 7 | 23·57 | | 22 | 0 | 36·49 | | | 17 | 50·68 | | | 11 | 6·43 |
| | | 17 | 19·16 | | | 10 | 32·12 | | 7 | 3 | 46·34 | | | 21 | 2·13 |
| | 7 | 3 | 14·75 | | | 20 | 27·74 | | | 13 | 41·99 | | 23 | 6 | 57·83 |
| | 7 | 13 | 10·34 | | 23 | 6 | 23·37 | | | 23 | 37·65 | | | 16 | 53·52 |
| | | 23 | 5·93 | | | 16 | 18·99 | | 8 | 9 | 33·30 | | 24 | 2 | 49·22 |
| | 8 | 9 | 1·53 | | 24 | 2 | 14·61 | | | 19 | 28·96 | | | 12 | 44·93 |
| | | 18 | 57·12 | | | 12 | 10·24 | | 9 | 5 | 24·62 | | | 22 | 40 64 |
| | 9 | 4 | 52·72 | | | 22 | 5·86 | | | 15 | 20·28 | | 25 | 8 | 36·35 |
| | | 14 | 48·31 | | 25 | 8 | 1·48 | | 10 | 1 | 15·95 | | | 18 | 32·06 |
| | 10 | 0 | 43·91 | | | 17 | 57·11 | | | 11 | 11·61 | | 26 | 4 | 27·77 |
| | | 10 | 39·51 | | 26 | 3 | 52·73 | | | 21 | 7 28 | | | 14 | 23·48 |
| | | 20 | 35·11 | | | 13 | 48·35 | | 11 | 7 | 2·95 | | 27 | 0 | 19·19 |
| | 11 | 6 | 30·71 | | | 23 | 43·98 | | | 16 | 58·62 | | | 10 | 14·91 |
| | | 16 | 26·32 | | 27 | 9 | 39·60 | | 12 | 2 | 54·30 | | | 20 | 10·62 |
| | 12 | 2 | 21·92 | | | 19 | 35·23 | | | 12 | 49·97 | | 28 | 6 | 6·33 |
| | | 12 | 17·52 | | 28 | 5 | 30·85 | | | 22 | 45·65 | | | 16 | 2·05 |
| | | 22 | 13·12 | | | 15 | 26·48 | | 13 | 8 | 41·32 | | 29 | 1 | 57·77 |
| | 13 | 8 | 8·73 | | 29 | 1 | 22·11 | | | 18 | 37·00 | | | 11 | 53 49 |
| | | 18 | 4·33 | | | 11 | 17·75 | | 14 | 4 | 32·67 | | | 21 | 49·21 |
| | 14 | 3 | 59·93 | | | 21 | 13·38 | | | 14 | 28·35 | | 30 | 7 | 44·93 |

*System II.*

| m | 1902. | d | h | m | 1902. | d | h | m | 1902. | d | h |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0·66 | Oct. | 16 | 10 | 58·83 | Nov. | 1 | 4 | 18·32 | Nov. | 16 | 21 |
| 6·38 | | | 20 | 54·59 | | | 14 | 14·11 | | 17 | 7 |
| 2·10 | | 17 | 6 | 50·34 | | 2 | 0 | 9·90 | | | 17 |
| 7·83 | | | 16 | 46·10 | | | 10 | 5·70 | | 18 | 3 |
| 3·54 | | 18 | 2 | 41·86 | | | 20 | 1·49 | | | 13 |
| 9·26 | | | 12 | 37·62 | | 3 | 5 | 57·28 | | | 23 |
| 4·99 | | | 22 | 33·38 | | | 15 | 53·07 | | 19 | 9 |
| 0·71 | | 19 | 8 | 29·15 | | 4 | 1 | 48·87 | | | 19 |
| 6·43 | | | 18 | 24·92 | | | 11 | 44·66 | | 20 | 5 |
| 2·16 | | 20 | 4 | 20·69 | | | 21 | 40·46 | | | 15 |
| 7·89 | | | 14 | 16·46 | | 5 | 7 | 36·25 | | 21 | 0 |
| 3·63 | | 21 | 0 | 12·24 | | | 17 | 32·05 | | | 10 |
| 9·36 | | | 10 | 8·01 | | 6 | 3 | 27·85 | | | 20 |
| 5·09 | | | 20 | 3·78 | | | 13 | 23·65 | | 22 | 6 |
| 0·83 | | 22 | 5 | 59·56 | | | 23 | 19·45 | | | 16 |
| 6·56 | | | 15 | 55·33 | | 7 | 9 | 15·26 | | 23 | 2 |
| 2·30 | | 23 | 1 | 51·11 | | | 19 | 11·06 | | | 12 |
| 8·04 | | | 11 | 46·88 | | 8 | 5 | 6·87 | | | 22 |
| 3·78 | | | 21 | 42·65 | | | 15 | 2·67 | | 24 | 8 |
| 9·52 | | 24 | 7 | 38·43 | | 9 | 0 | 58·48 | | | 18 |

*System II.*

| 1902. | d | h | m | 1902. | d | h | m | 1902. | d | h | m | 1903. | d | h | m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dec. | 2 | 15 | 0·28 | Dec. | 14 | 5 | 3·77 | Dec. | 25 | 19 | 7·46 | Jan. | 5 | 23 | 15·43 |
| | 3 | 0 | 56·11 | | | 14 | 59·61 | | 26 | 5 | 3·31 | | 6 | 9 | 11·28 |
| | | 10 | 51·95 | | 15 | 0 | 55·45 | | | 14 | 59·16 | | | 19 | 7·13 |
| | | 20 | 47·78 | | | 10 | 51·29 | | 27 | 0 | 55·01 | | 7 | 5 | 2·99 |
| | 4 | 6 | 43·61 | | | 20 | 47·13 | | | 10 | 50·86 | | | 14 | 58·84 |
| | | 16 | 39·45 | | 16 | 6 | 42·98 | | | 20 | 46·71 | | 8 | 0 | 54·69 |
| | 5 | 2 | 35·28 | | | 16 | 38·82 | | 28 | 6 | 42·56 | | | 10 | 50·54 |
| | | 12 | 31·12 | | 17 | 2 | 34·67 | | | 16 | 38·41 | | | 20 | 46·39 |
| | | 22 | 26·95 | | | 12 | 30·51 | | 29 | 2 | 34·26 | | 9 | 6 | 42·24 |
| | 6 | 8 | 22·79 | | | 22 | 26·35 | | | 12 | 30·11 | | | 16 | 38·10 |
| | | 18 | 18·63 | | 18 | 8 | 22·20 | | | 22 | 25·96 | | 10 | 2 | 33·95 |
| | 7 | 4 | 14·46 | | | 18 | 18·04 | | 30 | 8 | 21·81 | | | 12 | 29·80 |
| | | 14 | 10·30 | | 19 | 4 | 13·89 | | | 18 | 17·66 | | | 22 | 25·65 |
| | 8 | 0 | 6·14 | | | 14 | 9·74 | | 31 | 4 | 13·51 | | 11 | 8 | 21·50 |
| | | 10 | 1·98 | | 20 | 0 | 5·58 | | | 14 | 9·37 | | | 18 | 17·36 |
| | | 19 | 57·82 | | | 10 | 1·43 | 1903. Jan. | 1 | 0 | 5·22 | | 12 | 4 | 13·21 |
| | 9 | 5 | 53·66 | | | 19 | 57·28 | | | 10 | 1·07 | | | 14 | 9·06 |
| | | 15 | 49·50 | | 21 | 5 | 53·12 | | | 19 | 56·92 | | 13 | 0 | 4·91 |
| | 10 | 1 | 45·35 | | | 15 | 48·97 | | 2 | 5 | 52·77 | | | 10 | 0·76 |
| | | 11 | 41·19 | | 22 | 1 | 44·82 | | | 15 | 48·62 | | | 19 | 56·61 |
| | | 21 | 37·03 | | | 11 | 40·67 | | 3 | 1 | 44·47 | | 14 | 5 | 52·46 |
| | 11 | 7 | 32·87 | | | 21 | 36·52 | | | 11 | 40·32 | | | 15 | 48·32 |
| | | 17 | 28·71 | | 23 | 7 | 32·36 | | | 21 | 36·17 | | 15 | 1 | 44·17 |
| | 12 | 3 | 24·56 | | | 17 | 28·21 | | 4 | 7 | 32·02 | | | 11 | 40·02 |
| | | 13 | 20·40 | | 24 | 3 | 24·06 | | | 17 | 27·88 | | | 21 | 35·87 |
| | | 23 | 16·24 | | | 13 | 19·91 | | 5 | 3 | 23·73 | | 16 | 7 | 31·72 |
| | 13 | 9 | 12·08 | | | 23 | 15·76 | | | 13 | 19·58 | | | 17 | 27·68 |
| | | 19 | 7·92 | | 25 | 9 | 11·61 | | | | | | 17 | 3 | 23·43 |

The quantities in the ephemeris are to be interpolated directly for the times for which they are required, the equation of light having been already applied.

The position of *Jupiter's* North Pole is assumed to be R.A. $17^h\ 51^m\ 59^s{\cdot}49$, N.P.D. $25°\ 26'\ 25''{\cdot}3$ at the beginning of 1902, and R.A. $17^h\ 51^m\ 59^s{\cdot}75$, N.P.D. $25°\ 26'\ 26''{\cdot}0$ at the beginning of 1903.

P denotes the position-angle of the northern extremity of *Jupiter's* axis, reckoned eastward from the northernmost point of the disc.

$L-O+180°$, $\Lambda-O+180°$ are the jovicentric right ascensions of the Earth and Sun respectively, reckoned in the plane of the

uator from O, the point of the vernal equin
rthern hemisphere; B, *B* are the jovicentric de
Earth and Sun above the planet's equator.
opted values of the diameters at distance 5·2c
38″·419; Polar 35″·945. The sources from
s are derived were given last year.
umed time for light to traverse the unit dista
s being the same value as that used by Mr. Mar
es the jovicentric angle between the Earth and S
es the position-angle of the point of greatest
oned eastward from the northernmost point
lso gives the position-angle of the shadows o
easured from the satellites themselves.
tained from B by the formula tan B′=sec $\epsilon_o$ t

$\epsilon_o=\frac{a}{b}=\frac{15\cdot53}{14\cdot53}$. Since B, B′ can never exceed
take the tangents as proportional to the a
suffices in practice to find B′ by the fo

. B′ is the eccentric angle of the centre

e call B″ the jovigraphical latitude of the cen
en we can find B″ by the formulæ:

$B'=\sec^2\epsilon_o \tan B$ or $\tan B''=\sec\epsilon_o \tan B'$.

gitudes of *Jupiter's* central meridian are com
ered values of the rates of rotation and of the
n the two adopted systems. The addition

on September 30, making the Belt nearly touch the south Temperate Band. The longitude of this swelling (System II.) was about 194°.

Observers are reminded that the Jovian system will be presented edgewise in 1902, and a watch should be kept for mutual occultations and eclipses of the satellites.

It will be remembered that the late Mr. Marth attached particular value to measurements of the latitudes of their shadows while crossing the disc of *Jupiter*, for the purpose of improving our knowledge of the positions of their orbit-planes.

A list of times of elongation of the fifth satellite is given in the *Connaissance des Temps* for 1902.

It may be mentioned here that the *Connaissance des Temps* for 1899 and following years gives ephemerides for the satellites of *Mars*, *Saturn*, *Uranus* and *Neptune* in the same form as those formerly contributed to the *Monthly Notices* by Mr. Marth.

*Benvenue*, 55 *Ulundi Road*, *Blackheath*, *S.E.*:
1901 *October* 16.



# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. LXII. DECEMBER 13, 1901. No. 2


Dr. J. W. L. GLAISHER, M.A., F.R.S., PRESIDENT, in the Chair.

William John Greenstreet, M.A. (Camb.), Marling School, Stroud, Gloucestershire,

was balloted for and duly elected a Fellow of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

William Ambrose Kibbler, M.B., Ashby House, 3 Manor Road, Stamford Hill, N. (proposed by the Rev. T. E. R. Phillips) ;

C. F. Sandberg, M.A. Oxon., Magdalen College School, and 6 Parks Road, Oxford (proposed by H. C. Plummer) ;

Albert Walter, Royal Alfred Observatory, Mauritius (proposed by E. W. Maunder) ; and

Edward Fawcett White, Navigation Department, Merchant Venturers' Technical College, Bristol (proposed by Captain P. Thompson).

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Eighty presents were announced as having been received since the last meeting, including amongst others :—S. Newcomb, "The Stars, a Study of the Universe" (presented by the publishers).

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## *Contribution to the History of the Reflex Zenith-Tube.*

By S. C. Chandler, Assoc. R.A.S.

(*Communicated by the Astronomer Royal.*)

It may not be uninteresting to the Society to lay before them the following note concerning an instrument, notable in English astronomy, whose history has passed through various phases—in the beginning of high hope, later of grievous perplexity, finally of severe disappointment. Mr. Adams, in 1852, concluded his address of presentation of the medal to Mr. Peters with the following words: "We may hope that the beautiful reflex zenith telescope of the Astronomer Royal . . . will enable us ere long to take many firm, though long-reaching, steps into regions of space hitherto untrodden." Subsequently, however, the successive discussions of Main and Downing gave unacceptable results, as is well known, and in 1882 the observations were silently abandoned.

In the *Astronomical Journal*, No. 511, it is shown that this instrument, so far from being a failure, has provided us with an invaluable record of a phenomenon which was unsuspected at the time the observations were made, and which has within the last decade become the subject of the most active and general inquiry; namely, the relative motions of the earth's axes of rotation and figure. There is one topic, not there touched upon, on which a few words here may not be superfluous. The object of this note is to expose directly and analytically how the anomalous parallax of $\gamma$ *Draconis* and aberration were brought about.

In *Astronomical Journal*, vol. xii., p. 177, it is shown that the coefficients of the sine and cosine of the Sun's longitude,

$$Y = qu - p\pi + \eta, \quad Z = pu + q\pi + \zeta \quad . \quad . \quad (A)$$

are functions of four unknown quantities; namely, the parallax $\pi$, the correction $u$ of the assumed aberration-constant, and the coordinates of the annual component of the motion of the pole,

$$\eta = -r_2 \sin G', \quad \zeta = -r_2 \cos G'$$

$r_2$ and $G'$ being furnished by observation, and the coefficients

$$p = \sin \epsilon \cos \delta - \cos \epsilon \sin \alpha \sin \delta, \quad q = \cos \alpha \sin \delta$$

from known quantities. For $\gamma$ *Draconis* we have (1865) $p = +0{\cdot}965$, $q = -0{\cdot}022$. From *Astronomical Journal*, No. 511, p. 59, we take:

| | 1857–63. | 1864–70. |
|---|---|---|
| $r_2$ | 0″·166 | 0″·134 |
| $G'$ | 323° | 313° |

consequently $\eta$ $+0''\cdot100$ $+0''\cdot098$
„ $\zeta$ $-0''\cdot133$ $-0''\cdot091$

which are the values of Y and Z if $u$ and $\pi$ are zero. If, on the contrary, we ignore $\eta$ and $\zeta$, as was in effect done in the earlier attempts to get aberration and parallax, we have from (A)

$$u = \frac{qY+pZ}{p^2+q^2}, \quad \pi = \frac{qZ-pY}{p^2+q^2}$$

which would give, introducing the above data and the assumed aberration $20''\cdot505$,

| | Aberration. | Parallax. |
|---|---|---|
| | " | " |
| 1857–63 | 20·365 | −0·100 |
| 1864–70 | 20·408 | −0·099 |
| Mean . . | 20·386 | −0·100 |

The values actually found by Downing, from the observations 1857–75, were

$20''\cdot378$ $-0''\cdot131$

thus a satisfactory agreement with the foregoing, the differences being nominal and doubtless due to the fact that he included the observations for 1871–75, which I did not.

The above demonstration, while possibly unnecessary, is not uninteresting as showing explicitly how the former anomalous results are harmonised with the truth as now perceived. The old discussions are practically attempts to find four unknowns from two equations.

It is certainly a comfort that the perplexing enigma connected with the Reflex Zenith-Tube has finally found its answer, and that the patience of the astronomers who executed this laborious series meets at last an adequate reward of useful result. The question naturally arises in the mind whether a resumption of observations by this method, with an instrument optically capable of more easily showing $\gamma$ *Draconis* in the daytime, and an earnest attention to securing a higher precision as regards accidental error of observation, would not be a worthy undertaking.

If such a resumption of the investigation under these more favourable conditions be feasible, it scarcely needs to be suggested that it ought properly to extend to all the stars passing the Greenwich zenith bright enough for reflection-observation on a dark sky. This would determine both the aberration and the latitude-variation, which is not possible with a single star. At least two groups of stars in opposite right ascension would be desirable. Assuming the limit of brightness to be $6\frac{1}{2}$ magnitude, a list of all the stars that might be embraced in such a programme is appended.

| Mag. | (1905·0) α h m s | δ ° ′ | |
|---|---|---|---|
| 6·0 | 0 19 8 | + 51 29·6 | — |
| 6·1 | 1 44 52 | 28·0 | — |
| 6·6 | 1 58 0 | 30·7 | — |
| 5·4 | 4 59 14 | 28·4 | Fl. 9 Aurigæ. |
| 6·6 | 5 39 29 | 29·0 | — |
| 6·5 | 5 43 23 | 29·2 | — |
| 6·6 | 7 26 33 | 31·1 | — |
| 6·8 | 10 24 18 | 28·8 | — |
| 6·0 | 13 59 28 | 25·7 | — |
| 2·5 | 17 54 24 | 30·0 | γ Draconis. |
| 6·8 | 18 59 59 | 29·6 | — |
| 4·0 | 19 27 19 | 31·5 | ι Cygni. |
| 6·4 | 20 32 4 | 31·6 | — |

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*the Velocity of α Persei.* By H. F. Newall.

owing additional observations of the velocity of

| Plate Number. | | | Velocity relative to Earth. | Correction for Earth's Orbital velocity. | Velocity relative to Sun. |
|---|---|---|---|---|---|
| F. 155 | | 13·25 | + 7·3 | − 9·4 | −2·1 |
| F. 159 | | 17·24 | +13·7 | −11·0 | +2·6 |
| F. 160 | | 19·25 | +12·5 | −11·9 | +0·6 |
| F. 162 | | 21·23 | +12·0 | −12·7 | −0·7 |
| F. 180 | 1901 Feb. | 12·39 | +25·9 | −25·8 | +0·1 |
| F. 181 | | 13·40 | +24·5 | −25·9 | −1·4 |

These results were very nearly ready for publication in February last, but the appearance of the new star in *Perseus*, and stress in connection with preparations for the eclipse expedition, which started from England on March 11, stood in the way of the necessary completion of the discussion, and to my regret it was left unfinished. Meanwhile, Professor Vogel and Professor Campbell kindly responded with great promptness to the expression that I gave in my previous note to the hope that observations of the star would be secured at other observatories; and I would here express my obligations to them. Their published results (*Sitzber. Berlin Akad.* 1901, p. 51, and *Lick Obs. Bull.* No. 4) show that no support is found either at Potsdam or at the Lick Observatory for my suggestion that the velocity varies periodically.

My later observations given above showed at once that they would not fit either of the periods, 4·2 days or 16·8 days, which I had suggested as possible.

As Professor Vogel has pointed out, I have used a linear dispersion about two and a half times that obtained in the instrument he has used for making his observations at Potsdam; it is about twice as great as that used by Professor Campbell.

While it is clear that the larger dispersion might bring to light changes that were not detected on photographs of smaller scale, it is also evident that the use of it would be attended with greater risks arising from temperature changes, &c. Every precaution has been taken to avoid risks of this kind, short of putting in an arrangement for generating heat inside the non-conducting covering which surrounds the spectroscope. The photographs were obtained with all care and afford apparently excellent material for the measurements to be made. The spectrum of *α Persei* is admirably adapted for an accurate investigation; for the lines are numerous and distinct, and in spite of an exhaustive study of the material I have at present no clue as to the cause of the discrepancies.

*le Method of Accurate Surveying with an Ordinary*
By H. H. Turner, D.Sc., F.R.S., Savilian
r.

urements of photographs have proved so accurate and
in astronomy that they will probably be found useful
The present paper suggests an extension of the
opted for treatment of the Astrographic Chart plates
l surveying ; and although not definitely astronomical,
ises out of astronomical work, it may perhaps not
be communicated to this Society.

*of the camera in surveying hitherto.*—Instruments
or using the camera in terrestrial surveys have
arted with the theodolite as a substructure. Now
lite is primarily designed to measure *angles*, and I
ow in the present paper that the use of angles is
, and only complicates the formulæ. It is not an
but the tangent of an angle which arises funda-
the work, when a view of any kind is projected on
nd if we keep to plane geometry with straight lines
formulæ, we get much simpler formulæ ; just as in
l work it simplifies matters to use rectilinear
instead of curvilinear or angular. This has not been
far as I have been able to find out) in surveying any
t was in astronomy ; indeed existing instruments for
ic surveying often contain a "scale of tangents"

P fall at G. We shall suppose for the present that there is no optical distortion, *i.e.* that the images on the plate all fall truly on rays through the point A ; and the way of dealing with any deviation from this law will be considered later.

Let AE be drawn normal to the plate from the centre A. The point E, which is the foot of the normal from the lens centre on the plate, is of some importance and will be called the plate centre. Let AE=$f$. It is the focal length of the lens when an infinitely distant object is in focus, and in all cases is of comparable dimensions with this focal length.

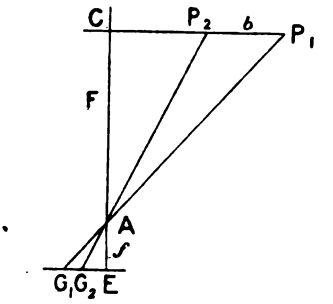



FIG. 1.

The coordinates of P in space referred to axes AC, CP are

$$AC=F \text{ say, and } CP=X$$

and if we put EG, the measured distance of the image from the plate centre, equal to $x$, we have of course

$$x/f=X/F \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

From measurements on a single photograph we can get nothing more than this—the ratio X/F. To determine either of these completely we must take another photograph. Now it will clearly be of advantage to keep one or other of these quantities the same in both pictures. If we keep F the same we must move along a line parallel to the plate; if X the same, along a line perpendicular to the plate. Both these plans have special advantages, and we will consider them each in turn.

5. *The parallactic or stereoscopic method.*—Let us move the camera a measured distance $b$ to the right, keeping it parallel to itself. (The practical method of securing these conditions will be considered presently.) Then this is equivalent to supposing all the objects in the field of view moved a distance $b$ to the left

Denote the first and second positions by the
2 ; so that we have

$$\left.\begin{aligned} x_1/f &= X_1/F \\ x_2/f &= X_2/F \\ X_1 - X_2 &= b \end{aligned}\right\} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

$$(x_1 - x_2)/f = b/F \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

$$F = \frac{bf}{x_1 - x_2} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

constant for the pair of pictures. Thus to get the
f any object measured in a direction perpendicular
or the base, we measure the distances $x_1$ $x_2$ on the
ake their difference, and divide it into a constant.

$$X_1 = \frac{F}{f} \cdot x_1 = \frac{b x_1}{x_1 - x_2} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

ther coordinate (on the ground plan) of the object is
ally simply. Finally if we want the elevation of
all its height above the horizontal plane AGE
lens centre Y, and let $y$ be the measured height
above the line EG on either picture. Then clearly

$$Y = \frac{F}{f} \cdot y = \frac{b y}{x_1 - x_2} \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

would correspond to an error of 1/250 of the distance at a mile away, say 20 feet; and this is considerable accuracy. For other distances the error is as the square of the distance, *e.g.* at 5 miles it would be 500 feet.

7. *Second method. Advance in direction of view.*—The formulæ, when we keep X the same, are equally simple. We have

$$\left.\begin{aligned} f/x_1 &= F_1/X \\ f/x_2 &= F_2/X \\ F_1 - F_2 &= b, \text{ say} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Thus $$f\left(\frac{1}{x_1}-\frac{1}{x_2}\right)=b/X$$

or $$\left.\begin{aligned} X &= \frac{b\,x_1x_2}{f(x_2-x_1)} \\ F_1 &= \frac{bx_2}{x_2-x_1} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

and obviously $$Y_1=\frac{F_1}{f}y_1$$

The weak point in this case is that when $x_1=0$ we have $x_2-x_1=0$: that is, the method fails to give results for objects near the middle of the picture. There is, however, a corresponding advantage in the adjustments of the instrument, as will presently appear.

8. *Necessary conditions.*—It remains to consider how to secure the necessary conditions, which are:

(1) To measure a base of a given length in a given direction. The practical difficulties here are such as need not concern us.

(2) To keep the camera parallel to itself. For this the camera should first be fitted with at least two cross levels. No reversal of the levels is necessary, as it is only necessary that the camera should be parallel to itself; but if the levels have serious errors, the survey will not be referred to a true horizontal plane. The levels will check the parallelism so far as rotations about horizontal axes are concerned. As regards that about a vertical axis,

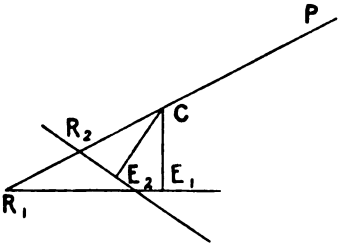



FIG. 2.

remark that in the second method this adjustment is checked by the pictures themselves, for objects at the middle of the picture

be displaced at all ; and any displacement at once of parallelism. There is no difficulty in applying the for lack of parallelism, which takes a form already astronomical work. Let C be the centre of the lens, , the correct and displaced positions of the plate ; P hich forms images at $R_1$, $R_2$.

$$\left.\begin{aligned} E_1R_1 &= f \tan \theta \\ E_2R_2 &= f \tan (\theta - a) \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

he angle of displacement and may be supposed small.

$$E_2R_2 = f \tan \theta - fa \sec^2\theta$$

$$E_2R_2 - E_1R_1 = -fa\left[1 + \left(\frac{E_1R_1}{f}\right)^2\right] \quad . \quad . \quad . \quad (10)$$

splacement of an object near the middle of the plate nstant and measures the constant $fa$ with accuracy. her objects we multiply this correction by a simple

he first or stereoscopic method the determination of ental adjustment is not quite so simple, as all the the picture are shifted. A compass-needle on the ld not give the parallelism with sufficient accuracy ase is small. If there is one object in the picture nce is accurately known, the error of parallelism ound ; but if the object is near, a considerable

faces ; $L_1$ giving a picture on a plate AB, and $L_2$ on a plate BC. Let both pictures be taken without moving the camera. Then advance 100 feet, either in the direction BC or BA, and take another pair of pictures. If in the direction BC, then the pair with lens $L_1$ will give an accurate measure of the error of parallelism, which can be used to reduce the pair of stereoscopic pictures taken with $L_2$. It should be remarked that fig. 3 is only the ground plan of the cameras, which can be separate instruments firmly attached together with lenses at right angles. The image formed by one lens could be reflected by a diagonal reflector on to the same plate as that formed by the other.

(*c*) If only one camera is available it can be made to serve as a pair at right angles, even without any accurate instrument for measuring angles. Nail two laths with straight edges at right angles to one another on a board, and place some fiducial edge of the camera against each in turn, taking care not to move the board between the exposures. There should be no real difficulty in securing this adjustment even in field work.

10. *Form of camera.*—It will be seen that no special form of camera is necessary, and probably the most convenient will be the simplest : a rectangular box with no focal adjustment, or better, two such firmly attached at right angles, would give good results. Either films or plates might be used, but if films, then a plate of réseau lines should be fixed immediately in front of the film. In any case there should be at least one set of cross-wires to identify the origin for measures on the two plates.

11. *Optical distortion* need not be a trouble even though it be large, as may happen with a wide-angle camera. It should be *determined* thus : expose the camera to any view first with the aperture which is to be used in practice ; secondly with a pinhole stop : measures of the two pictures will at once give the correction for distortion at different distances from the optical centre.

12. *The measures* should be made by the method of rectangular coordinates, in any of the ways found convenient for star measures. A series of réseau lines impressed on the plate is almost a practical necessity, but there is no need to dwell on points of this kind which have already been worked out in the case of star-measures. It may be remarked incidentally that a good deal of useful work might be done without taking photographs at all, by measuring the positions of images on the ground glass of the camera, or a substitute. If the substitute be a photograph of réseau lines, and an eyepiece with a cross-scale attached to it be placed carefully in contact with this photograph, so as to focus objects in the field of view, the réseau lines, and the cross-scale altogether, measures of position could be made at once, and a few such would doubtless be a valuable check on the photographic measures.

13. *General plan of survey.*—The following general plan of operations may thus be suggested. On any route, however

there will be opportunities for selecting pairs of curately in the line of march, and 100 feet apart ther convenient distance). By pairs of photographs ove the positions of near objects can be determined those of distant objects not so well. But these latter on many photographs, and we thus get longer bases to determine them more accurately. A compass ched to the camera, though useless for avoiding minute of orientation, would be very useful in comparing istant stations.

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*curacy of Measures on Photographs: Remarks on Papers by M. Loewy and Mr. H. C. Plummer.* By R. Hinks, M.A.

supplementary number of the *Monthly Notices*, 1901 . 618), Mr. H. C. Plummer has recently discussed the rate memoir by M. Loewy, "Sur la précision des s coordonnées rectilignes des images stellaires," in the cular of the *Conférence astrophotographique inter- de Juillet* 1900. M. Loewy has sought to find a mula which shall give the probable error of the mean ber of settings upon a star image, in a number of ientations of the plate; and concludes that to avoid

ordonnée rectiligne, deux catégories d'erreurs : l'une, l'erreur accidentelle $E_a$, et l'autre, $E_s$, l'erreur systématique. . . . L'erreur totale $E_t$ se trouve donc exprimée par la formule

$$E_t = \sqrt{E_a^2 + E_s^2}. \text{ "}$$

Now it is evident at once, as Mr. Plummer has pointed out, that the expression "systematic" error is not used here in its ordinary sense ; truly systematic errors of course do not follow the law of distribution which is the basis of the method of least squares. And to destroy the validity of the above equation it would be necessary to show only that the distribution of error in photographic measures is not entirely accidental ; that it tends to be of opposite sign in opposite orientations of the plate for example.

On this point M. Loewy writes (1901 October 16) :

"Je saisis cette occasion de préciser d'avantage la principe qui m'a guidé dans l'établissement des formules.

"Une fois la moyenne d'une série de pointés formée, ce résultat est affecté de deux catégories d'incertitudes, l'une a pour expression $E_a/n$" [apparently a slip for $E_a/\sqrt{n}$] "et l'autre est représentée par $E_s$.

"$E_s$ est une erreur accidentelle d'une autre espèce affectant la moyenne. . . .

"Or, les expériences ont montré que, lorsqu'on répète les mesures dans une même orientation, avec un même observateur, après plusieurs mois d'intervalle, $E_s$ varie notablement. Pour ce motif, on préfère ne répéter une seconde fois la détermination des coordonnées rectilignes que plusieurs mois après l'exécution de la première série de mesures. . . . Il n'est permis ici de faire aucune supposition sur une loi quelconque qui relie entre elles les différents valeurs de $E_s$, soit en signe, soit en grandeur. $E_s$ est évidemment à considérer comme une erreur accidentelle d'un autre genre.

"Comme il convient, d'un côté, d'attribuer le maximum d'effet aux sources d'erreurs, et qu'il fallait d'un autre côté embrasser la généralité des cas, j'ai dû admettre qu'il n'existe aucun lien entre les $E_s$ relatives, aussi bien à différents observateurs qu'à diverses orientations, même si celles-ci diffèrent de 180°—ayant fait d'ailleurs, comme je l'ai dit dans ma dernière lettre, des expériences qui confirment cette dernière hypothèse."

These experiments are thus described in a former letter (1901 September 12) :

"On a généralement admis, ainsi qu'à Paris, que cette petite anomalie constante dans une orientation donnée, s'élimine dans la moyenne de deux séries de mesures faites dans des orientations différant de 180°. Comme cela a été expressément répété dans plusieurs endroits de ma note, on ne peut admettre *a priori* aucune hypothèse, quelque soit son degré de probabilité, lorsqu'il s'agit d'atteindre le dernier degré de précision.

ons fait sur cette question de nombreuses expéri-
vers appareils, et dans des conditions variées, et j'ai
lans le plus grand nombre des cas cette supposition
t inadmissible. On arrive *à peine* à une compensa-
d'erreurs que dans des cas exceptionnels. . . .
cliché que nous avons examiné, grace à ces qualités,
t dans les nombres relatifs aux positions différant
ues compensations ; mais elles sont de peu d'import-
ard de la somme totale des résidus. En effet
abord deux à deux la moyenne des résidus entre les
érant de 180°, et calculant après l'erreur probable,
e valeur à peine différente d'un centième de seconde
figurant dans ma note."

p briefly M. Loewy's view, it is necessary to con-
r systématique" as an accidental error of another
o say, differing from the accidental error deduced
rgence of successive pointings in a single orienta-
in the first place, experiments have shown that the
ror is certainly not really systematic, but varies
time, and secondly because a rediscussion of the
n the supposition that there may be some compen-
he plate is reversed leads to the original result.
n absolute contradiction to the result which Mr.
uced from the same figures. And the discrepancy
est importance because the validity of M. Loewy's
equation turns upon it. If the "accidental error of
" can be shown to be not really accidental, if the

separate exposures, as well as in the mean for the three; and I propose therefore to discuss only the measures of observer A.

In Tables VI. 1 and VI. 2 of M. Loewy's paper we find the individual measures made upon the first and second images of each of the 82 stars, in four orientations, 0°, 90°, 180°, and 270°. Forming afresh the means for observer A only, we obtain from his measures 656 residuals. The point to be determined is whether these tend to be of opposite signs in opposite orientations. We will consider separately the pairs of opposite orientations 0° and 180°, 90° and 270°, and divide each series into two classes—I., in which the residuals in opposite orientations are of the same sign; II., in which they are of different signs. If the residuals are distributed impartially, both as to sign and magnitude, these two classes will be equal. We will further subdivide each class according to the magnitude of the sums of the pairs of residuals, without regard to sign. Again, if the residuals are distributed impartially, large numerical sums will occur with equal frequency in each group.

The results of this analysis are as follows:

*Classification of Numerical Sums of Residuals in Opposite Orientations.*

| | 0° and 180°. | | 90° and 270°. | |
|---|---|---|---|---|
| Exposure 1. | I. Same Signs. | II. Opposite Signs. | I. Same Signs. | II. Opposite Signs. |
| Sums between 0 and 19 | 13 | 7 | 7 | 9 |
| 20 „ 39 | 7 | 16 | 8 | 24 |
| 40 „ 59 | 8 | 12 | 9 | 13 |
| 60 „ 79 | 2 | 7 | 2 | 5 |
| 80 „ 99 | 1 | 3 | 1 | 2 |
| 100 and over | 0 | 6 | 0 | 2 |
| | 31 | 51 | 27 | 55 |
| Exposure 2. | | | | |
| Sums between 0 and 19 | 13½ | 9½ | 14½ | 9½ |
| 20 „ 39 | 13½ | 18½ | 15 | 13 |
| 40 „ 59 | 3 | 6 | 3 | 14 |
| 60 „ 79 | 0 | 7 | 0 | 9 |
| 80 „ 99 | 0 | 4 | 0 | 2 |
| 100 and over | 1 | 6 | 1 | 1 |
| | 31 | 51 | 33½ | 48½ |

The halves appear because in some cases one residual is zero, and the pair has to be divided between groups I. and II.

These numbers give abundant support to two conclusions:

(1) That in pairs of opposite orientations the residuals are more frequently of opposite sign than of the same sign.

(2) That when the residuals are large, and their numerical sum correspondingly large, they are almost always of opposite sign.

to me, then, that these residuals cannot be treated as
n any sense whatever; that they do not come under
on of the ordinary law of accidental errors at all;
nsequently M. Loewy's fundamental equation is not
lo not therefore find myself in agreement with
ıer when he says: "We may follow M. Loewy in
ıe accidental and systematic errors by $E_a$ and $E_s$
, and the total probable error by $E_p$ and admit that
$E_p^2$." This is indeed in obvious contradiction to his
hat there is a striking compensation of errors when
measured in reversed positions—a conclusion which
upported by the figures given above.

scarcely avoid coming to the conclusion that it will
hesitate before committing oneself to the arduous
which M. Loewy recommends; and this view is sup-
he circumstance that there is another category of
nich he has not up to the present time taken any
real error of position of the star image on the plate,
causes as irregularity in the size or distribution of
s of silver in the image, or local shrinkage of the
n which is not eliminated by the use of the réseau.
ssible to discuss the magnitude of this source of error
y's plates, because he has given the measures of one
only, and one cannot discover whether there has
n a slight change of orientation, &c., in the interval
exposures which would affect the differences between
tes with an error which is a linear function of those

mean will be a criterion of the inaccuracy which arises from all those categories of error, accidental error of setting, systematic error of measurement due to personality or otherwise, and systematic error of position of image due to irregularity or local defects. It is, then, of no consequence to examine elaborately the divergences from the mean of settings on a single exposure.

*Cambridge Observatory:*
1901 *December* 12.

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## *The Spectrum of Nova Persei from* 1901 *February* 28 *to April* 26. *With Appendix on the Spectrum in September.*

Rev. W. Sidgreaves, S.J., Stonyhurst College Observatory.

### *Introduction.*

In "Notes on the Spectrum of *Nova Persei*," presented at the March meeting of the Society, it was briefly stated that the notes referred chiefly to photographs obtained with an objective prism of 4 inches aperture mounted on the finder of the large equatorial. It is necessary to preface the present paper by a more detailed description of this prismatic camera, on account of the difficulties which had to be overcome in order to secure accurate settings of the spectrum on the photographic plate. The importance of this adjustment is many times greater when the object-glass is corrected only for the visual rays than when a correcting lens for the photographic rays is employed, on account of the steep inclination of the plate to the optic axis of the lens, required for the simultaneous focus of the several photographic rays.

The camera is provided with a rotating frame for carrying the dark slide, and a graduated circle for setting the angle of inclination required. Another slide of the same dimensions as the dark slide carries three platinoid wires drawn taut over screw-heads—a pair of parallel wires, and one at right angles to the pair. When this slide is in the camera the wires lie in the plane to be occupied by the photographic plate. Its structure is simple, consisting of a plate of hard wood, with a central hole over which the wires are drawn, and side rails bringing up the sliding thickness to that of the dark slide. The space between the rails is left open at the ends to admit the light of a taper to illuminate the wires.

When the star is in the field its spectrum is seen with an eyepiece at the back of the camera as a sharp colour line, red at one end and blue at the other, together with the wires. The camera is set in position with reference to the prism by turning it in its adapter to bring the pair of lines parallel to the colour line image of the star; and the spectrum is brought into position on the

plate by setting it between the parallel wires, with the cross wire cutting out the yellow part of the spectrum. In this operation the eye has to be satisfied that there is no bluish-green on the red side, and no orange-yellow on the violet side of the cross line. This cross wire or bar is fixed not centrally in the field, but considerably to the side of the less refraction of the prism, in order to keep the photographic spectrum nearer the centre of the plate.

The length of the spectrum is 21 mm. from H$\beta$ to H$\nu$. About one-fifth of this is by the secondary spectrum of the object-glass, brought into service by the inclination of the plate.

With this inclination at 36°·5, H$\beta$ and the region at and beyond H$\epsilon$ can be brought into simultaneous focus, and a shorter focus of about a millimetre brings the intervening region to the best definition. The latter adjustment has been employed on every date except February 28, when an error was made with the focus rack. The former was employed only on March 3, 12, and 16. The difference between the two focal lengths is not too great to hinder a compromise between them; and this has resulted occasionally from imperfect settings when the light of the star was too weak, or that of the sky too strong for seeing easily the yellow part of the spectrum.

The tube of the telescope is mounted so as to turn easily on its axis. This is a convenience for an adjustment to compensate for changing refraction, when the star is low and away from the meridian; and by it the slant of the spectral lines of the *Nova* has been greatly diminished, but only fully corrected on the later exposures.

The succession of fine nights in the earlier part of February came to an end on the 20th, just before the new star made its appearance. It was followed by a week of unbroken cloud until 10.30 P.M. of the 28th; and since then no opportunity has been lost of observing the spectrum of the star, in order to collect all information possible about the subsequent changes in its structure, which had been very great and very rapid in the early days of its life.

It was during the preceding fine week that the experimental work for selecting the angle of inclination of the plate and finding the focal adjustments had been completed for the ordinary photographic rays; but nothing had been done for an orthochromatic plate. And since the inclination of the plate for the green and yellow rays would have to be practically nothing, it was decided to make no attempt on these with the prismatic camera, but to leave them to the direct compound prism attached to the greater telescope; and thus the angle of inclination, on which all measurements in the spectra so much depend, has not been altered since its final selection. But only one isochromatic plate (Edwards) has been employed on the *Nova*, viz. on February 28, while the star was bright enough to give its green spectrum, to which the plate is only feebly sensitive.

*Discussion of the Spectrographs.*

1. *The continuous spectrum* of the star is remarkable for its great relative strength in the ultra-violet region. Compared with other stars, whether of the white or yellow type, the density of the silver deposit in the region near and beyond the head of the hydrogen series should be accompanied by a density in the blue region, at least equal to the darkest parts of the negative between Hβ and Hγ. It was, therefore, at the beginning, a question between two opposing interpretations of the spectrum: Whether it was to be called a strong, continuous spectrum crossed by broad absorption bands and the bright hydrogen series, or a weak continuous spectrum with bright bands. The former interpretation seemed to be more in keeping with the earliest observations at Edinburgh and Harvard College. But there are two regions on the plates, which cannot be accounted for on the supposition of a strong continuous spectrum. These are the region near Hβ on the violet side, and the region between Hδ and Hε: these are much too weak, when compared with the strongest parts between Hβ and Hγ, to be considered continuations of the same spectrum. The later photographs of March 22, 25, and 28 seemed to decide the question in favour of the bright blue bands by their greater prominence on a weaker continuous spectrum.

2. *The bright hydrogen lines* are probably the broadest radiation lines yet observed in stellar spectroscopy. In the following table their widths on the negatives are given in millimetres, with a column of means reduced to spectral widths in wave-length micromillimetres:—

TABLE I.

*Widths of Hydrogen Bright Lines.*

| | On March 3 mm. | 16 mm. | 27 mm. | April 4 mm. | 16 mm. | Mean mm. | μμ |
|---|---|---|---|---|---|---|---|
| Hβ | 0·44 | 0·34 | 0·35 | 0·33 | 0·29 | 0·35 | 3·5 |
| Hγ | ·68 | ·63 | ·56 | ·48 | ·53 | ·58 | 3·5 |
| Hδ | ·78 | ·79 | ·59 | ·64 | ·53 | ·67 | 3·4 |
| Hε | ·83 | ·81 | ·72 | ·59 | ·68 | ·73 | 3·2 |
| Hζ | ·96 | ·89 | ·72 | ·72 | | ·82 | 3·3 |
| Hη | ·78 | ·77 | ·60 | | | ·72 | 2·7 |

These figures show an apparent gradual shrinkage of the lines. But it may be doubted whether this is a real contraction or only the result of decreasing intensity. The widths on March 3 and 16 are exaggerated by over-exposure of the hydrogen spectrum; and those of March 27 and April 4 may be broadened in the same way by a rate of trail slower than was intended for the diminished magnitude of the star. On the other hand, the trail was too quick on April 16, through an accidental omission to adjust the clock rate; but the definition

ect on this plate, and the broad lines are sharply
h both sides, so that there was no hesitation in setting
eter line upon them. It is not impossible that these
measures stripped of all photographic encroachment
al indefinition.

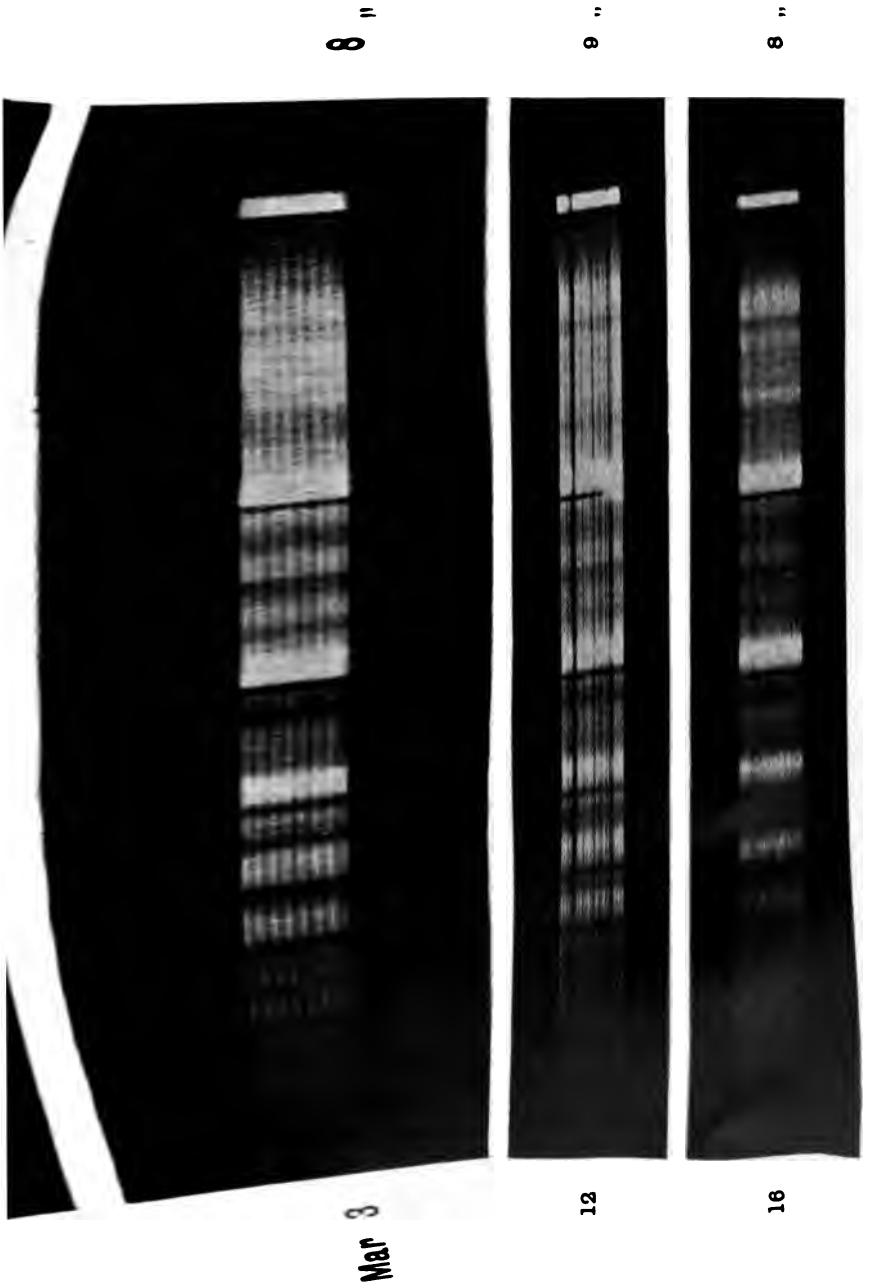
in the structure of the lines are apparent on the
ne of these are of undoubted radiation origin, and
be only photographic freaks. In the following
otful appearances will be omitted, or noted as such.

ruary 28 H$\beta$ and H$\zeta$ are very clearly crossed by
orptions. The same reversal is just seen in H$\delta$,
n H$\gamma$, but not at all in H$\epsilon$ or H$\eta$.

rch 3 the same reversal is seen in H$\beta$ only, and it
ader on the plate at 12 hours than on the earlier
ours.

rch 12 there is a notable change : the reversal in
e, and in its place there is a line of *greater* intensity,
d by two others, one near each margin of the broad
same triple structure appears also in H$\gamma$ and H$\delta$, but
other lines. H$\epsilon$ is composed of two equal parts of
ength sharply distinct, with the stronger half on the

ch 16 the triple structure is much weaker, and the
led appearance of H$\epsilon$ is changed to a maximum
arer to the red side, shading off both ways ; and all
nes, excepting H$\beta$, show this distribution of density.
ch 20 the triple intensity is still seen in H$\gamma$, and the




SPECTRUM OF NOVA PERSEI, 1901



3. *The calcium line* K was bright and broad like the hydrogen bright lines on February 28 and March 3, and since then it has slowly faded away. It was marked with a central reversal, and the more refracted half was much the weaker. This was the first to disappear; it was weaker on March 7 and 8; and on March 12 it was extinct; but the reversal remained as a companion to the stronger component. On this date the reversal was a strong, sharp, and thin line on the more refracted side of its bright companion, resembling the dark companions of the hydrogen bright lines, but retaining its position of the K wave-length relatively to the bright hydrogen series. It is again apparently marked on the plate of March 16, but only about half across the plate, viz. during the first part of the trail; and so, if real, it was extinct at 8.30 P.M., the trail having started at $8^h$ and ended at 9.15. Its position is exact; and it is very nearly, if not perfectly, parallel to H$\epsilon$. It divides nearly centrally a feebly bright space, which may be calcium radiation nearly extinct; and this trace of calcium light is seen again, and for the last time, on a plate of the 21st without the reversal.

4. *The dark hydrogen lines* do not appear to have been, at any time, very broad; not much broader than those of $\alpha$ *Geminorum*.

In the first photographs of February 28 and March 3 there is nothing against the possibility of a much greater width masked by the overlapping broad bright lines. But on the later photographs they stand apart from the bright lines, with perfectly sharp edges, and the broad bright lines fade away towards them in the same manner as they fall off on the red sides. This is very clearly seen in H$\delta$, H$\epsilon$, and H$\zeta$ in the enlarged spectrographs of March 12, 16, and 21.

At the beginning these dark lines appeared to grow in strength, between February 28 and March 8; but the evidence for this is not conclusive: the apparent increase of intensity may be a photographic effect due to difference of exposure. But after March 8 their decline was regular and uninterrupted; they slowly disappeared, together with the bright calcium line K. On March 12 they had lost their centres, and appeared as well-defined double lines separated by a thin clear reversal. The more refracted components were much the weaker and were the first to disappear. They had lost much on the 16th and were quite extinct on the 20th, when the red side components formed the series of sharp thin lines, which were seen for the last time on the 21st.

5. *The separation of the bright and dark hydrogen lines* is still the most important feature of a *Nova's* spectrum. The separation in this spectrum is so great that it is not necessary to wait for direct determinations of displacement with reference to terrestrial hydrogen light in order to arrive at sufficiently approximate conclusions, on Doppler's principle, regarding the line of sight velocities. The measured length of the hydrogen

mpared with that of a reference star, on the method Orbinsky,* may be considered enough for the inves- velocity by small dispersion, when an error of 50 o great consequence.

investigation the reference star selected was *a Cygni*, of its sharply defined hydrogen lines. Four expo- been made with the correct *setting*, described in the , and three with a faulty setting, more at fault than accidentally. All these have been carefully tested ometer stage; and the agreement of the measured n H$\beta$ to the several hydrogen lines up to H$\mu$ is the greatest difference between the same measures of the plates being ·02 mm. Repeated measures of tervals on the photographic plates of the *Nova* have and the results are summarised in the following hich the figures of column j are the measured lengths the successive hydrogen lines in the spectrum of l those of column ij are the corresponding lengths in e series of *Nova Persei*. In column iij the differences and in column iv the deduced velocity. In columns j the bright lines are treated in the same way as the j, ij, iij, and iv :—

TABLE II.

*Radial Velocity.*

| Dark line spectrum. | | | Bright line spectrum. | | |
|---|---|---|---|---|---|
| | | Deduced velocity | | | |

high velocities in opposite directions, together with an approximate measure of their magnitudes. Those from the dark-line spectrum rest on the measures of a single plate for the greater intervals at Hι, Hκ, Hλ, Hμ, and on three plates for the shorter lengths.

There was little difficulty in setting the micrometer wire on the absorption lines, which are sharp and well defined. It was different with the broad bright lines, but for these many plates were available; and the mean intervals obtained from them should give a fairly reliable resulting velocity, seeing that the individual measures are not very erratic. The following table contains an abridged analysis of these measurements, designed to show the relation between the *means* and the separate measurements :—

TABLE III.

*Analysis of the Measurements for the Bright-line Velocity.*

Relation between the *means* and *separate measures.*

| From Hβ to | | Hγ | Hδ | Hε | Hζ | Hη |
|---|---|---|---|---|---|---|
| Mean length ... ... | mm. | 6·95 | 11·33 | 14·23 | 16·15 | 17·54 |
| Number of plates affording a measure | | 26 | 22 | 23 | 14 | 12 |
| Range, or difference between extreme measures ... ... | mm. | ·07 | ·09 | ·13 | ·21 | ·33 |
| Number of measures giving the opposite sign ... ... | | 1 | 1 | 3 | 0 | 1 |

The resulting velocities were in both cases unexpected, as may be seen by a reference to the writer's earlier notes on the spectrum of *Nova Persei* in the *Monthly Notices*,* in which it was stated that the whole of the relative velocity would probably have to be attributed to the dark-line source; the measured lengths from Hβ to the successive bright lines being the *same* in the spectrographs of the *Nova* and of the comparison stars. The *differences* have been found by comparisons with the thinner and more sharply defined hydrogen lines in the spectrographs of *α Cygni*, obtained at the end of May and beginning of June.

There is no evidence from this investigation of any change of the velocity of the bright-line source between March 3 and April 26; but, so far as the measures can be trusted, the evidence is for a constant velocity. Of the total number of plates measured, eighteen belong to March and eight to April; and the mean lengths are compared in the following table :—

TABLE IV.

| From Hβ to | Hγ | Hδ | Hε | Hζ. |
|---|---|---|---|---|
| Number of plates in March ... | 18 | 17 | 17 | 12 |
| „ „ April ... | 8 | 5 | 6 | 2 |
| Mean length in March ... | 6·95 | 11·33 | 14·23 | 16·15 |
| „ „ April ... | 6·95 | 11·33 | 14·22 | 16·17 |

* April 1901, Note 2.

*eneral spectrum of the star* is treated as two distinct
ed for convenience the *approaching* spectrum and the
ectrum. The receding spectrum is taken to consist
of bright lines. These are, with few exceptions, like
n lines, broad and somewhat diffuse ; and they are
be under the same physical conditions which affect
and breadth of the hydrogen lines.
ve-lengths are quoted for the centres of the broad
entre of bright H$\beta$ has been employed for the fiducial
receding spectrum, and the wave-lengths have been
r velocity-displacement.
y, in the approaching spectrum the centre of dark H$\beta$,
H$\gamma$, according to the circumstances of the plate, has
or the fiducial point, and the displacement correction
ordingly.
spectra, therefore, the tabulated wave-lengths are, as
n be obtained from the spectrograms, the undisturbed
s of the origins, or as they would be found from a
ource. A test line for the corrections of the receding
the reversed K, which is a thin sharp line on the
arch 3, 12, and 16, and owing to the applied correction
he table with its undisturbed wave-length.
les are to be found at the end of the paper ; and the
the columns and explanations are given in the notes
of the tables.* In the first column of the bright-line
possible origins are noted, which are collected together
wing list. The wave-lengths are taken from Watts'
pting those of helium, which are the strongest lines in

| Nova. λ | Width. μμ | Helium. Max. I. 10. | Oxygen. Max. I. 10. | Magnesium. Max. I. 10. | Vanadium. Max. I. 10. |
|---|---|---|---|---|---|
| 447·9 | 0·7 | | | 448·1 | |
| 457·2 | 1·7 | | | 457·1 10 | |
| 458·6 | Thin | | | | 458·5 6 |
| 464·0 | 3·0 | | 463·7 6<br>464·1 7<br>464·8 9 | | |
| 471·7 | Thin | 471·3 3 | | | |
| 491·9 | 3·4 | 492·2 4 | | | |
| 501·5 | 3·2 | 501·6 6 | | | |
| | | | | 517·9 9 | |
| 516·7 | 3·9 | | | 518·3 10 | |

| Also on March 28 | | | |
|---|---|---|---|
| 385·7 | *Cyanogen* | 385·7 | 7 |
| 386·1 | ,, | 386·2 | 8 |
| 388·2 | ,, | 388·3 | 10 |

An interesting result appears by collating the two tabulated spectra : viz. that the broad bright line near Hδ and the broad absorption on its more refractive side, which are well seen in the enlarged photograph of March 3, &c., are complements, having, practically, the same wave-length, 407·0 and 406·9, in their respective spectra. The line has a strong claim to represent the oxygen triplet, as noted in the table above ; and therefore oxygen appears to share the physical conditions of hydrogen in the *Nova*.

Other complementary lines, indicated in the same manner, are the fine lines

| | | | |
|---|---|---|---|
| 461·5 | 459·6 | 438·6 bright | on March 17. |
| 461·4 | 459·3 | 438·5 dark | |

7. *The alternating spectrum* of the *Nova* was first observed as such on March 28, when the photograph of the preceding day showed that the remarkable change seen in those of the 22nd and 25th was not a permanency. The changed spectrum is to be found on Plate 2 of enlarged photographs, on the dates March 25 and 28, which are in all details the same as the photograph of the 22nd. Its leading features are the broad blue lines or bands in conspicuous contrast on a much enfeebled continuous spectrum, and an apparent great extension of the bright hydrogen line Hζ. On the same plate is shown the return to the older spectrum on the 27th ; and the two similar spectra of the 21st and 27th show that the change from the old to the new spectrum on the 22nd and 28th was very rapid.

The three dates, March 22, 25, and 28, on which the new spectrum was first seen, corresponded closely with the observed

minima in the star's light curve; and the star was supposed to be a variable with a corresponding variable spectrum. But the three-day period failed at the end of the first week of April, the alternations of light intensity became irregular, and the spectrum followed the irregularities of the light. In the following table the dates of the two forms of the spectrum are given from March 21 to April 26; opposite each date the magnitude of the star is quoted from the measures made at the Radcliffe Observatory, Oxford,* and the items are written in the order of

TABLE VI.

*The Alternating Spectrum.*

| Star's Magnitude. | On Date | |
|---|---|---|
| 3·91 | March 21 | |
| 3·98 | ,, 27 | |
| 4·08 | April 4 | |
| 4·19 | ,, 1 | Old type. |
| 4·28 | ,, 5 | |
| 4·36 | ,, 23 | |
| 4·49 | ,, 13 | |
| 4·57 | ,, 9 | Both types partly. |
| 4·61 | March 28 | |
| 4·67 | April 12 | |
| 5·15 | March 25 | |
| 5·20 | ,, 22 | |
| 5·32 | April 16 | New type. |
| 5·55 | ,, 26 | |
| 5·83 | ,, 20 | |
| 5·86 | ,, 25 | |
| 6·00 | ,, 21 | |

decreasing magnitudes. These figures show that the *new* spectrum is not connected with any phase of the light curve, but follows the absolute light intensity. All the *new* spectra have appeared when the star was less than 4·57 mag., and the *old* spectra only when the star was brighter; and this magnitude seems to indicate the temperature at which the change takes place: for the spectrum on this date, April 9, belongs partly to both types, the *old* and the *new*, as may be seen by a reference to the writer's note 4 in the May number of *Monthly Notices*, p. 463.

Of the blue bands in the new spectrum, the first (counting from H$\beta$) is a new radiation, $\lambda$ 468·7 and the stronger one near it, $\lambda$ 464·1, is also new if compared with the spectrum of

* *Monthly Notices*, 1901 April and May.

Mar. 21
25
27
$H_\gamma$ $H_\delta$ $H_\varepsilon$ $H\zeta$ $H\eta$ $H_\theta$ $H_\iota$
$H_\beta$
$H_\zeta$
$8\frac{1}{2}$ "
$8\frac{1}{4}$ "



March 21 ; but it is within the very wide band at λ 465 $\mu\mu$ of March 3 and February 28. The fifth band (third in the order of brightness) is the helium line 4472, and is probably new ; but it is broad enough to contain the magnesium line 448, which was the centre of the band on and before March 21. The less refrangible helium line at 471·8 is only just discernible in the negative of March 28, not seen so well as on March 16 and preceding dates.

The apparent extension of Hζ is also a new radiation, probably the cyanogen band between λ 388 $\mu\mu$ and 386. It is crossed by three distinct brighter lines, 388·3, 386·1, and 385·7, agreeing closely with the strong CN lines of intensities 10, 8, 7 in Watts' Index of spectra ; but there is no trace of the line 387·1 of intensity 9. The band is brighter than Hε and nearly equal to Hδ in intensity.

Hε itself is too strong both with reference to Hδ and to the part of Hζ which is not overlapped by the CN band ; and this disproportion in the gradations of intensity becomes a marked characteristic of the new spectrum on April 16, 20, 25, and 26, when Hε appears on the plates with double the strength of Hδ, although at the low altitude of the star on these dates the line should have been obliterated by atmospheric absorption. It is therefore probable that this is another new line.

## *Review.*

At the end of a rather long study of the photographic plates of the *Nova's* spectrum, two questions appear to stand over, about which some expression of opinion may be expected. The first of these regards the high velocities : is Doppler's principle of motion in the line of sight to be accepted or rejected for the true cause of the great displacements of the hydrogen lines ? And the second is about the new type spectrum first photographed on March 22 : what is its teaching ?

In an article "The New Star of the New Century" in the May number of *The Observatory*, the writer acknowledged his own dissatisfaction with the Doppler explanation of the velocities, mainly on account of the want of a general law, according to which the high velocity of the dark-line source in all new stars should be towards our Earth. This want was supplied by Lord Kelvin in a conversation at the Royal Society Soirée in May, and with his permission was explained verbally at the following meeting of the Royal Astronomical Society. The explanation subsequently appeared in the June number of *The Observatory*, and is reprinted here with the kind permission of the editors :—

"Granted a collision between two stars, the immediate result would be scattering of matter in all directions, with greatest velocities in directions nearly perpendicular to the line of relative motion of the two impinging bodies. These velocities of fragments may largely exceed that of the relative motion of the

efore impact. The matter thus scattered would
ly of the broken bits but also of their decomposed
Ubiquitous hydrogen would be there to begin
ch also would be liberated. A part of this gaseous
e raised to high temperature, with little associated
y; and a part would be urged outwards at high
little rise of temperature; and this, the cooler
e the absorbing material. The absorber therefore
be in motion towards us, and the radiant matter
at comparative rest. The application of Doppler's
becomes simple. The mass of hydrogen moving
he white-hot centre would absorb shorter wave-
white radiation, and would *not* absorb the radiation
ydrogen. The bright lines would therefore be little
splaced on the continuous spectrum, and the dark
lways be shifted to the side of greater refraction."
anation requires the actual collision of two solid
ount for the enormous velocities needed for the
anation: no multitude of smaller masses in collision
the same effect; and no intrusion of a big solid
ocean of nebulous matter would be more successful.
otheses the fatal assumption has to be made of
igh velocity in a given direction. On the other
collision seems not only possible, but almost a
rence from time to time in the vast and crowded
Milky Way; and no imagination can picture the
shock of two worlds meeting.
d question regarding the alternating spectrum is

tions was near the combining temperature of some of the mixed gases, the spectrum would also oscillate with the temperature.

This hypothesis has apparently been revived more recently * in a modified form, which does not appear to suit so well the requirements of oscillation. The difficulty comes in when, for the sudden expansion, radiation is substituted for the cooling agent. This is necessarily a slow process, and something is wanted to keep back the chemical action until the mass of elements ready for combination is great enough for the enormous evolution of heat required. Without this the result is only a retardation of the rate of cooling, as crystallisation arrests the fall of temperature of a cooling liquid. It is true that water may be cooled down several degrees below its freezing temperature, and when the ice forms the temperature rises; and we have, on a small scale, in the opposite process of heating water, an irregularly oscillating temperature about the boiling-point, when the generation of steam becomes rapid. The reach from these small operations to those that would be required for an oscillating stellar temperature is very great; but every supposition made implies some forbidding magnitude, and here the greatness is not greater than the step from the laboratory to the stellar experiment.

*Stonyhurst College Observatory:*
*1901 July.*

## *Appendix.*

On August 24 and 27, September 5 and 11, and October 4 and 6, good photographs of the *Nova's* spectrum were again obtained, and these show further changes which may be found to be connected with the fall of temperature during the interval.

The photograph on August 24 shows all the broad lines distinctly, but not the finer details: the rate of trail was too slow, and the stronger bands were over-exposed. The plate of September 11 shows, on the contrary, the details of the stronger bands distinctly, but the trail was too quick for the weaker bands.

The reproductions on Plate 3 are from the photographs of August 27 and September 5. The first of these is by the Hilger compound prism (marked H in the tabulations) on the large equatorial; and the second is by the Thorp 4-inch objective prism, T. The first shows the lines better in the blue and green, but loses the violet and ultra-violet by the great absorption of its dense flint glass. The second supplies the violet end of the spectrum. But all the bands can be seen in both.

Other photographs on September 14, 15, 21, and 24, in less favourable atmospheric conditions, serve to show that the spectrum has remained constant in September. It still retains

* Lohse, cited by Vogel, *A.N.*, 3701, and *Edinburgh Review*, 1901 July, p. 89.

aracter of broad bright lines on a distinct continuous
ich perhaps cannot be called weak considering the
de of the star. The principal changes are contained
ng notes :—

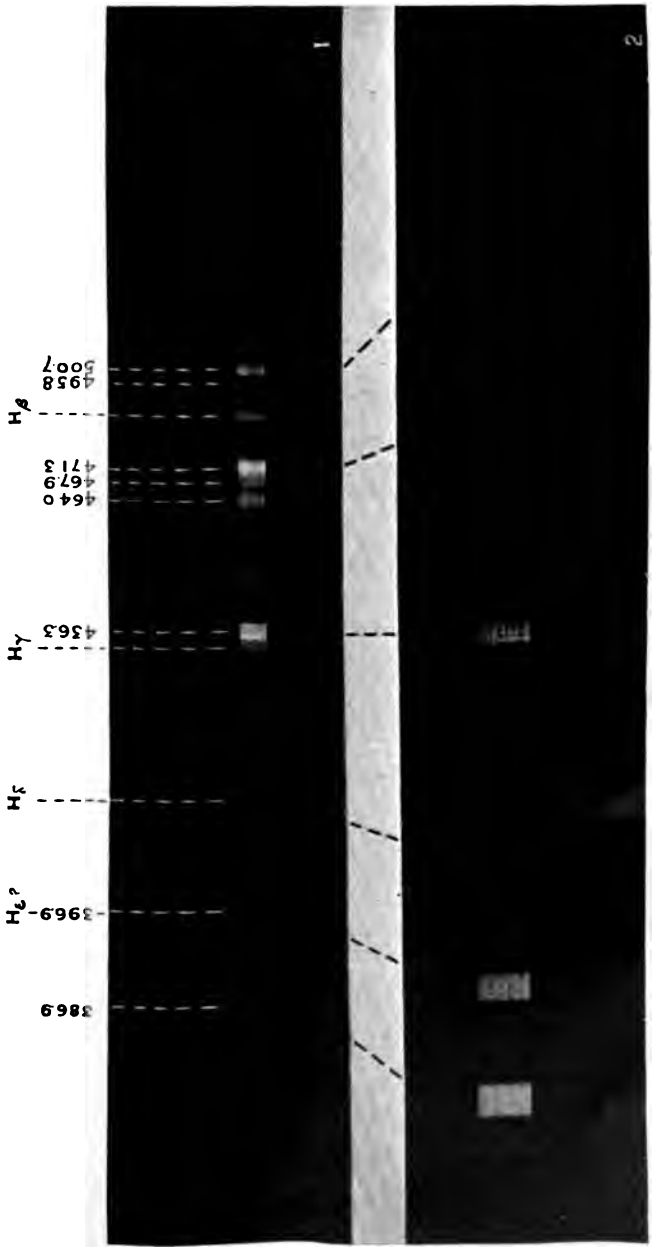
drogen lines are no longer the prominent features.
k uniform bands, and are apparently dying out
anything of their width.

o significant lines 500·7 and 495·8 have come into
n place of the two helium lines 501·7 and 491·9,
sappeared.

ne helium line 447·2 has died out, and another, a
n the laboratory, 471·3, has grown from a feeble
e one of the strong lines of the spectrum : it is the
he isochromatic plate by the prism H.

ong broad blue band 468·7 of the new spectrum in
pril has contracted to a narrower and weaker band,

drogen line Hγ and its companion band at λ 436·4
ed conditions of relative intensity, the latter now
e stronger. These two broad lines have been close
om March 21. They overlap one another, and the
lges can be seen in the photographs of March 21
t dates. They are very clear in the photographs
eptember, and October, and in these the over-
s much stronger than the united intensities ; it has
ed as a bright line in the structure of the band
proved to be so by a photograph on September 15,
ppears as a strong line on this band when Hγ and




SPECTRUM OF NOVA PERSEI ON AUG. 27 AND SEPT. 5, 1901

1. BY COMPOUND PRISM ON LARGE EQUATORIAL
2. BY OBJECTIVE PRISM ON 4-INCH FINDER

*Stonyhurst College Observatory*



distinctly marked on an ordinary quick plate employed with the prismatic camera, although the sensibility of the plate to this radiation is very small. But this plate affords a direct comparison between the intensities of the *Nova* and the corresponding places in the continuous spectrum of *α Cygni*. The two spectra are not on the same plate, but both plates are Mawson's quickest, and the exposures and developments were practically the same, the exposure on *α Cygni* having been made with the object of bringing out every possible detail at the two extremities of the spectrum. In this comparison the line 386·9 of the *Nova* is decidedly stronger, and the line 500·7 a little stronger than the corresponding parts of the spectrum of *α Cygni*. The preference therefore is given to the ultra-violet line, and the probable order of real intensities in the *Nova*, beginning with the strongest, is 386·9, 500·7, 495·8, 472·0, and 436·4.

These and the weaker lines are entered in Table VII. under the name of spectrum III.; and the line-details of broad bands are given separately. These wave-lengths are not corrected for any velocity displacement, no indication of displacement having been found. On the photographs of August 27 and September 5, H$\beta$ and H$\delta$ appeared with well-defined edges admitting of accurate settings of the micrometer line, and no relative displacement was found.

We have, at Stonyhurst, no photographs of the spectrum between April 26 and August 24; and, unfortunately, no orthochromatic plate was employed in March or April: so that our series of photographs leaves it uncertain whether the new lines 495·8 and 500·7 on August 27 belong to the second spectrum, or to a further decrease of stellar temperature. The change at the position of H$\epsilon$, where the band 396·9 is so much stronger than the other hydrogen lines, appears to be connected with the star's magnitude 5·32 on April 16, when H$\epsilon$ was stronger than H$\delta$; it was not so on a later date (April 23), when the star was much brighter, and it was not so on an earlier date (March 22), when the star was a little brighter—·12 mag.—and it was always so later, when the star was less bright than 5·32 mag. But the structure of this band, and the similar structure of the bands 386·9 and 436·4, belong probably to a later stage of the star's decline.

Of the changes, therefore, enumerated, perhaps only the following are to be associated with the lower temperature of the later spectrum: 1, the development of the band 472, which was weak and hazy in the second spectrum, into a strong band containing a stronger line at 471·3; 2, the shrinking of the strong band 468·7 of the second spectrum to a weaker and thinner band at $\lambda$ 467·9; and 3, the quadruple structure of the three bands 386·9, 396·9, and 436·4.

The other changes may have taken place at higher temperatures. Thus the compact form of the bands is apparently a marked feature of the later spectrum—a change from diffusive

p margins ; but from the photograph on April 16 pears to have been assumed at a higher temperature, r's magnitude was 5·32. Similarly, the predominat- s of the lines 386·9 and 396·9 appear to indicate a y permanent state of radiation, dating from the the second spectrum, and brought into relief by other lines, rather than by any growth of their own

*Conclusion.*

e admitted that the latest spectrum of *Nova Persei* tributed to a better understanding of its earlier has raised new questions, or possibly only emphasised ch need solutions before we can read with certainty s from temporary stars. The great width of the leading difficulty at the beginning, but it was not ble. Enormous velocity, or enormous pressure, could ered improbable physical facts, associated with the rmous evolution of heat implied by the rapid rise of n nothing to the brightest in the sky. But the width of the lines during the last five months ened the besetting difficulties : high velocity and e present less difficulty when lasting for a short e hydrogen lines are as broad to-day as they were of April, and show no signs of losing width : they ly dying out uniformly, without thinning at the

weakest of four becoming stronger than the united intensities of the rest. And as a helium line, it would be a naturally weaker line in full strength while the strongest are wanting. But of these as possible origins helium, perhaps, is the more probable. Taken for the helium line 396·5, there would be, in all, three helium lines in the spectrum, 386·8, 396·5, and 471·3; all composite lines, but not all symmetrically marked, and not symmetrically widened, the centres of the three bands in the *Nova* being to the red sides of the helium lines at 0·1, 0·4, and 0·6 $\mu\mu$ respectively.

It may be in the future of spectroscopic work to discover the physical conditions of radiant matter when giving these anomalous spectra; but the simpler supposition of an unknown common origin of the three bands 386·9, 396·9, and 436·4, suggested by their perfect similarity in form and structure, may be true, and is perhaps more in keeping with our imperfect knowledge of the luminous spectrum.

But what is the origin? Should it be called Nebulum? Professor Pickering, writing at the end of June, points out the likeness, with some exceptions, between the spectrum of the *Nova* and that of the nebula N.G.C. 3918.* The likeness has improved since then in some respects, for the relative strength of the line 500·7 is better, and the line 436·4 is clearer: the former is now considerably stronger than H$\beta$, and the latter much stronger than H$\gamma$. And there is no mention of the line 464·0, which was the strongest of the blue bands in the second spectrum, and is still equal to H$\gamma$; while the other strong line 468·7 has either completely fallen out, or is masked by two side lines, a weaker one at $\lambda$ 467·9, and the practically new line 472·0, which is now the strongest of the blue bands. But is not the likeness spoiled by the great width of the *Nova's* lines, and by the composite structure of four of the strongest bands?

TABLE VII.

*Bright-line Spectrum of Nova Persei*, 1901.

| Spectrum | I. | | | II. | | | | | | III. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Prism | T. | | | T. | | | T. | | | H. | | | T. and H. | | |
| Date | Feb. 28, Mar. 3, 12, 16, 21, 27. | | | Mar. 22, 25, 28. | | | Aug. 24, Sept. 5. | | | Aug. 27. | | | Oct. 4, 6. | | |
| Nova Magnitude | Mag. >4·57. | | | Mag. <4·57. | | | 6·21. | 6·42. | | 6·48. | | | 6·86. | | |
| Possible Origins. | $\lambda$ $\mu\mu$ | W $\mu\mu$ | $i$ 10/1 | $\lambda$ | W | $i$ | $\lambda$ | W | $i$ | $\lambda$ | W | $i$ | $\lambda$ | W | $i$ |
| | 376·4 | 1·7 | 2 | | | | | | | | | | | | |
| H$\theta$ | 379·8 | 2·6 | 8 | | | | | | | | | | | | |
| H$\eta$ | 383·5 | 2·9 | 5 | | | | | | | | | | | | |
| H$\zeta$ | 388·9 | 3·3 | 6 | 386·9<br>388·9 | 6·0 | 8. | 387 0 | 2·9 | 10 | 387 | 2·3 | | 386·8 | T. | 2·5 |

* *A.N.*, 3735, p. 234.

| | II. | | | | III. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | T. | | | T. | | H. | | T. and H. | |
| r. 27. | Mar. 22, 25, 28. | | | Aug. 24, Sept. 5. | | Aug. 27. | | Oct. 4, 6. | |
| 7. | Mag. $<4\cdot57$. | | | 6·21. | 6·42. | 6·48. | | 6·86. | |
| t o/1 | λ | W | i | λ | W i | | | λ | W i |
| 5 | | | | | | | | | |
| 7 | 397·1 | 3·4 | 8 | 396·8 | 3·2 8 | 396·8 | 2·5 | 396·8 T. | 2 3 |
| 3 | 403·1 | 2·2 | | | | | | | |
| 4 | 407·0 | | | | | | | | |
| 8 | 410·2 | 3·0 | 9 | 410·2 | 3·0 2 | 410·1 | 2·3 | | |
| 6 | 414 | 3 | 1 | | | | | | |
| 6 | 419 | 3 | 1 | | | | | | |
| 6 | 423·5 | 3 | 1 | | | | | | |
| 6 | 428 | 3 | 1 | | | | | | |
| 10 | 434·1 | 3·1 | 10 | 434·1 | 2·6 2 | 434·0 | 2·5 | 434·1 H. | 2·3 |
| | 436·4 | 3·0 | 3 | 436·4 | 3·0 7 | 436·3 | 2 8 | 436·3 H. | 3·0 |
| 7 | 438·4 | 2·5 | 2 | | | | | | |
| | 447·1 | 3·2 | 4 | | | 447·1 | 2·7† | 447·1 | 2·7† |
| 7 | | | | | | | | | |
| 7 | 452·3 | 3·3 | 1 | | | | | | |
| 7 | 457·1 | 3·3 | 2 | | | | | | |

*Structure of Bands—Bright Lines.*

| l at | | 386·9. | 396·9. | | 436·3. |
|---|---|---|---|---|---|
| | Mar. 28. | Sept. 5, 11, Oct. 4, 6. | Sept. 5, 11, Oct. 4, 6. | Aug. 27. | Sept. 5. |
| rism | T. | T. | T. | H. | T. |
| C. N. lines. | | | | | |
| | | 385·6 edge | 395·6 edge | 434·9 edge | 434·9 edge |
| 385·7 | 385·7 strongest | 385·8 strongest | 395·8 strongest | 435·1 strongest | 435·2 strongest |
| 386·2 | 386·1 | 386·5 | 396·5 | 435·8 | 435·9 |
| 387·1 | | 387·1 | 397·1 | 436·5 | 436·6 |
| | | 387·8 | 397·8 | 437·3 | 437·4 |
| 388·3 | 388·3 | 388 2 edge | 398·2 | 437·7 edge | 437·8 edge |

| l at | 438·4. | 457·2. | 465·0. | 467·9. | | 471·9. |
|---|---|---|---|---|---|---|
| | Mar. 3. | Mar. 12, 16. | Mar. 12, 17. | Aug. 27. | Aug. 27. | Sept. 5. |
| rism | T. | T. | T. | T. | H. | T. |
| | 436·1 | 456·1 | 461·9 | 467·2 | 469·8 | 470·2 |
| | 438·6 | 457·5 | 463·2 | 468·1 | 471·2 strongest | 471·3 strongest |
| | 440·4 | 458·9 | 464·4 | | 472·4 | 472·3 |
| | 440·6 | | 466·0 | | | |
| | | | 468·3 | | | |

The wave-lengths of spectrum I. and II. are corrected for velocity-displacements. Spectrum III. has given no indication of velocity-displacement.

Prism H is a compound direct prism on the 15-inch O.G. equatorial.

Prism T is a 4-inch objective prism on a 4-inch O.G. finder.

In column W the widths of the lines are given in spectral micro-millimetres.

In column *i* the strongest line on the plate is indicated by the number 10, no allowance being made for the sensibility curve of the photographic plate. The numbers therefore in different columns are not necessarily comparable. The intensities by prism H are not entered, on account of the great absorption effect of the dense flint glass. On this plate the strongest lines are 471·3 and 436·4.

TABLE VIII.

*Dark-line Spectrum corrected for Velocity-displacement.*

| λ | | On Dates. | |
|---|---|---|---|
| 377·1 | $H_\iota$ | Mar. 3, 12. | Also $\kappa$, $\lambda$, $\mu$, $\nu$ on Mar. 12. |
| 379·8 | $H\theta$ | | All to Mar. 12 inclusive. |
| 381·6 | | ,, 12. | Very clear. |
| 383·6 | $H\eta$ | | All to Mar. 21 inclusive. |
| 386·7 | | ,, 12. | Clear. |

| | On Dates. | |
|---|---|---|
| Hζ | | All to Mar. 21 inclusive. |
| | Mar. 17. | Very clear fine line. |
| | „ 17. | |
| | „ 17. | |
| Hε | | All dates to Mar. 21 inclusive. |
| | , 17. | |
| | „ 12, 17, 20, 27. | Broad. |
| Hδ | | All dates to Mar. 21 inclusive. |
| | „ 12. | |
| Hγ | | All dates to Mar. 21 inclusive. |
| | „ 17. | Edge of Hγ. |
| | „ 17. | Very fine, not strong. |
| | „ 12, 17. | May be only continuous spectrum. |
| Hβ | | All up to Mar. 21 inclusive. |

*College Observatory :*
*October* 10.

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*ions of Nova Persei.* By J. E. Gore, M.R.I.A.

w this remarkable object on the evening of 1901 at 11.40 G.M.T., before I had heard of its discovery

*Observations of Nova Persei.*

| Date 1901. | Greenwich M.T. h m | Estimated Mag. | Notes. |
|---|---|---|---|
| Feb. 22 | 11 40 | 1·25 | A great new star in Perseus between β Persei and δ Persei; preceding, a little north of ν Persei. Much brighter than α Persei and about equal Pollux. |
| 23 | 11 25 | ... | Star still very bright but only seen through passing clouds; magnitude uncertain—seems at least first magnitude. |
| 24 | 10 45 | 0·24 | Nova seen between clouds; seems fully equal to Capella! Very bright; white with tinge of yellow. |
| 26 | 10 55 | 1·05 | Nova seen through intervals between fleecy clouds; seems much fainter; about one magnitude below Capella and one magnitude above α Persei; strong moonlight. |
| 27 | 11 45 | 1·73 | Nova about 1 step brighter than α Persei, much fainter than last night; Nova about same colour as Capella, more reddish than α Persei. Nova evidently fading rapidly. About 4 steps brighter than Algol. (N.B.—Algol *not* near a minimum.) Strong moonlight, but stars quite clear and easily observed. |
| Mar. 1 | 7 40 | 2·0 | Nova about 1 "step" below α Persei, but not much superior to Algol; clear sky in vicinity of Nova; strong moonlight. |
| | 10 38 | 2·13 | Nova about 2 steps less than α Persei. |
| 2 | 9 10 | ... | Nova about same brightness as last night but seen through fleecy clouds; estimate a little uncertain; strong moonlight. |
| | 10 5 | 2·08 | Nova 1½ step below α Persei, and 1½ step above Algol; sky clear round these stars. Nova more yellowish than α Persei. Seemed to twinkle a little more than α Persei. |
| 3 | 8 30 | 2·45 | Nova 3½ steps less than α Persei, and 1 step less than Algol; very clear sky; strong moonlight. Nova has still an orange tinge. |
| 7 | 7 5 | 2·88 | Nova about equal to ε Persei; but strong twilight, observation a little doubtful, but not very. |
| | 9 38 | 2·82 | Nova = ε Persei, and Nova 2½ δ Persei; sky clear in vicinity of Nova; Moon low. |
| 8 | 11 35 | 3·11 | Nova 2 steps below ε Persei and about equal to δ Persei; pretty clear in vicinity; moonlight. |
| 12 | 10 15 | 3·31 | δ Persei 2 Nova 6 ν; clear sky, no Moon. |
| 13 | 10 20 | ... | Nova seems a little fainter than last night, but some clouds about; observation doubtful. |
| 18 | 11 0 | 3·90 | Nova equal to ν Persei and considerably less than δ Persei; clear sky between passing clouds; no Moon. |

| ...en-ch T. m | Esti-mated Mag. | Notes. |
|---|---|---|
| 55 | 4·0 | Nova about 1 step less than $\nu$ Persei, l siderably brighter than 32 ($l$) Persei wit eye. Slightly reddish with binocular; n described as "claret" tint; very clear phosphorescent; no Moon; cold easterly |
| 15 | 3·85 | Nova 1 step *brighter* than $\nu$ Persei and brighter than $\kappa$ Persei with naked e binocular; sky clear from clouds, but hazy; crescent Moon. |
| 5 | 5·22 | (32) 2 (Nova) 3 (30 Persei), with binocula sky, but hazy; moonlight. Nova much than $\nu$ or $\kappa$ Persei. |
| 40 | 4·05 | Nova 1 step less than $\nu$ Persei, with naked binocular; much brighter than 32 Per rather more than half a magnitude ab Clear sky; moonlight. |
| 55 | 4·18 | Nova 2 steps below $\nu$ Persei; sky clear in of Nova. |
| 55 | 3·90 | Nova *much* brighter than 32 Persei and di brighter than last night; about equal to and (Nova) 1 ($\kappa$ Persei) with naked e binocular; clear sky; strong moonlight. |
| 5 | 5·13 | Nova = 32 ($l$) Persei, and (Nova) 3 (36 Pers binocular; clear sky; strong moonlight cold; Nova much fainter than $\nu$ and $\kappa$ Per |
| 25 | 4·73 | Nova considerably less than $\nu$ Persei, but |

| Date 1901. | Greenwich M.T. h m | Estimated Mag. | Notes. |
|---|---|---|---|
| Apr. 13 | 9 15 | 4·25 | $\nu$ 2 (Nova) 5 (32 Persei); hazy sky, but observation fairly good; no Moon; Nova visible to naked eye. |
| 14 | 10 ? | 5·44 | Nova = 30 Persei, or perhaps 1 step less; *very* clear sky; no Moon. |
| 15 | 10 15 | 5·37 | Nova = 30 Persei; seen between clouds. |
| 16 | 9 1 | 5·50 | (30 Persei) 1 (Nova), and Nova considerably less than 32 Persei; clear sky, but hazy and rather bright. |
| | 9 45 | 5·37 | Nova about equal to 30 Persei; very little difference between the two. |
| 18 | 9 20 | 4·39 | ($\nu$ Persei) 4 (Nova) 6 (32 Persei); hazy sky, but observation pretty certain. Nova again increased in brightness; visible to naked eye. |
| 19 | 8 55 | 5·33 | (32) 5 (Nova) 1 (30 Persei); sky clear, but rather hazy; no Moon; sky rather bright; Nova not visible to naked eye at $9^h\ 30^m$. |
| 20 | 9 7 | 5·50 | Nova about 1 step below 30 Persei, but sky very hazy, and thin clouds about; observation uncertain. |
| 21 | 10 2 | 5·37? | Nova about equal to 30 Persei, but very hazy sky; observation uncertain. |
| 25 | 9 55 | ... | Nova scarcely visible through haze, but seems to be faint; $5\frac{1}{2}$ mag. or less. |
| | 10 15 | $5\frac{1}{2}$ | |
| 27 | 9 13 | 4·48 | ($\nu$ Persei) 4 (Nova) $4\frac{1}{2}$ (32 Persei); pretty clear sky; moonlight. |
| 28 | 9 45 | 5·30 | Nova faint, about equal to 30 Persei, or 1 step brighter; moonlight and slight haze. |
| 30 | 9 37 | 5·37? | Nova faint in the moonlight, and haze and about equal to 30 Persei, but observation uncertain; scarcely visible in binocular. |
| May 1 | 9 37 | 4·5? | Nova barely visible through clouds of smoke, but it seems up again; perhaps 4·5 mag.; less than $\nu$ Persei. |
| | 10 20 | 4·56 | Nova brighter than 32, but less than $\nu$ Persei; moonlight and haze. |
| 5 | 1 25 | 5·50 | Nova 1 step below 30 Persei; clear sky; moonlight; star low but fairly well seen; faint, *much* fainter than $\nu$ Persei. |
| 6 | 10 35 | 5·5? | Some clouds. Nova seems still faint, about $5\frac{1}{2}$ mag., but uncertain. |
| July 31 | 12 35 | 5·87 | (30 Persei) 4 (Nova) 5 *b*; clear sky; strong moonlight. |
| Aug. 6 | 10 10 | 5·88 | (30 Persei) 5 (Nova) 6 *b*; clear sky; good observation. |
| 8 | 10 20 | 5·75 | (30) 3 Nova 6 *b*; sky clear but hazy; good observation. |

| Greenwich M.T. h m | Estimated Mag. | Notes. |
|---|---|---|
| 10 25 | 6·08 | (30) 5 (Nova) 3 *b*; clear sky; no Moon observation. |
| 10 20 | 6·12 | (30) 6 (Nova) 3 *b*; clear sky; no Moon. |
| 10 25 | 6·05 | (30) 6 (Nova) 4 *b*; clear sky; no Moon. |
| 10 20 | 6·12 | (30) 6 (Nova) 3 *b*; clear sky; no Moon. |
| 10 20 | 6·12 | (30) 6 (Nova) 3 *b*; pretty clear sky, but u air. |
| 10 10 | 6·08 | (30) 5 (Nova) 3 *b*; clear sky. |
| 10 15 | 6·21 | (30) 6 (Nova) 2 *b*; clear sky; moonlight. |
| 10 20 | 6·25 | (30) 7 (Nova) 2 *b*; clear sky but hazy. |
| 10 43 | 6·45 | Nova about equal to *b*; hazy sky and moonl |
| 11 0 | 6·22 | Nova 2 *b*; seen between drifting clouds. |
| 12 10 | 6·22 | Nova 2 *b*; clear sky; moonlight. |
| 10 40 | 6·22 | Nova 2 *b*; pretty clear; moonlight. |
| 10 59 | 6·22 | Nova 2 *b*; clear; moonlight. |
| 9 25 | 6·50 | Nova = *b*; night hazy; no Moon. |
| 9 25 | 6·22 | Nova 2 *b*; pretty clear; no Moon. |
| 9 58 | 6·50 | Nova = *b*. |
| 8 50 | 6·50 | Nova = *b*; clear; no Moon. |
| 8 36 | 6·50 | Nova = *b*; clear sky; moonlight. |

## *The Observed Motion and Duration of the Radiant Point of the Perseids.* By W. F. Denning.

In recent years a considerable number of observations have been made of the great display of *Perseids* in July and August, and the time seems to have arrived when the results may be usefully summarised. The writer called attention to the motion of the radiant in 1877 August, and reobserved this peculiarity in 1878, 1880, 1885, 1886, 1887, and in several subsequent years. Mr. D. Booth at Leeds obtained some special observations in 1888 and 1891 in examination of this feature, and his figures closely accorded with those previously derived at Bristol (*Observatory*, vol. xi., p. 380).

In tracing the displacement of a radiant it is necessary to keep the observations for each night separate, so that the individual centres for a series of dates may be determined and compared. Before 1893 it appears to have been customary to combine the materials accumulated on several successive or bordering nights, and thus the radiant points, based on such collections, formed diffused positions giving little or no intimation of motion. The necessity of confining the reductions to shorter periods was, however, impressed upon observers, so that in and since the very favourable year 1893 the observations employed in the deduction of the *Perseid* radiant have usually been limited to a single night, and the places determined in this way have proved of much value as evidence in respect of the E.N.E. motion of the shower centre. In the summary which follows I have arranged the radiants observed at Bristol in and since 1874 according to the day of the month on which they were made, and in a separate table have given similar observations by others in and since 1893,* for comparison. It was thought essential to keep the two sets of positions distinct, inasmuch as the Bristol results, if incorporated with the rest, might have unduly influenced the mean values and the deductions based on them. In fact, it seemed safer to arrive at conclusions justified by independent testimony, and to show the degree of mutual corroboration existing between the results derived at Bristol and at other stations. On inspection of the tables this will be seen to be very satisfactory when the nature of the observations is considered. During the last ten years quite a large number of observers have distinguished and followed, as far as conditions permitted, the easterly drift of the radiant, and the rate and direction of the movement have been pretty accurately assigned. As an observational fact this motion cannot be questioned. The writer has long regarded it as one of the most palpable, as well as

* An exception has, however, been made in regard to Mr. Booth's results obtained in 1888 and 1891, as he fixed the place of the radiant from observations on single nights.

one of the most certain, features he has ever noticed in this field of observation. And this trait in the visible character of the *Perseids* is one which appears to be in significant harmony with theory.

Judging from the remarkable increase in meteoric observers in recent years there seems every reason to suppose that the *Perseid* shower (offering as it does a rich display, appearing regularly at the most congenial season of the year) will be more critically studied, and that its radiant point will often be traced as it passes from the southern stars of *Cassiopeia* along the northern borders of *Perseus* into *Camelopardalis*. No doubt this transitory character of the centre is not a feature which is apparent only in the behaviour of the *Perseids*. It is similarly exhibited by the April *Lyrids* and probably by certain other systems, but they are displayed so briefly and often so feebly that it is difficult to glean a sufficient number of well-observed meteors to fix their radiants accurately on nights near the limits of their visibility. On the other hand, a movable radiant is not a common feature, for certain well-defined showers, among which may be instanced the October *Orionids*, show stationary radiants. These peculiarities require further investigation in regard to many of the principal streams. It seems desirable that the *Quadrantids* or *Boötids* of January, the *Lyrids* of April, the *Aquarids* of May and July, the *Orionids* of October, the *Leonids* and *Andromedids* of November, and the *Geminids* of December should all be perseveringly watched in future years with particular regard to their visible durations and to the mobile or fixed radiants which they individually display.

The abbreviations in the list of *Perseid* radiants determined by various observers are :—

| | | |
|---|---|---|
| E. M. A. | ... | E. M. Antoniadi, Juvisy. |
| W. E. B. | ... | W. E. Besley, London, S.W. |
| E. R. B. | ... | E. R. Blakeley, Dewsbury. |
| D. B. | ... | D. Booth, Leeds. |
| J. H. B. | ... | J. H. Bridger, Farnborough. |
| H. C. | ... | H. Corder, Bridgwater. |
| W. D. | ... | W. Doberck, Hong Kong. |
| J. A. H. | ... | J. A. Hardcastle, Littlemore, Oxon. |
| A. S. H. | ... | A. S. Herschel, Slough. |
| W. H. M. | ... | W. H. Milligan, Belfast. |
| C. D. P. | ... | C. D. Perrine, Lick Observatory. |
| T. E. R. P. | ... | T. E. R. Phillips, Yeovil. |
| H. J. T. | ... | H. J. Townshend, Leeds. |

The observations at Bristol were made at Bishopston, a suburb about two miles north of the central part of the city. During the years from 1869 to 1901 inclusive I observed 8,002 shooting stars on the forty-three nights between July 11 and August 22 inclusive, and these included 2,856 *Perseids*.

With reference to the theoretical conclusions on the displacement of apparent radiant points there is a valuable paper in *Monthly Notices*, vol. lii., pp. 341–54, by the late Joseph Kleiber. Mathematical deductions are here compared with some observational results, and in the case of the *Perseids* they present an excellent accordance. Mr. Kleiber gives the computed place of the radiant on July 8 as 9°+46°, August 8 41°·5+57°·3, August 9 42°·9+57°·6, August 10 44°·2+57°·9, and August 16 54°+59°. Le Verrier first pointed out that theoretically such a displacement must occur, and in 1859 some visible indications of it were recognised by Professor A. C. Twining in America, but the observations were too meagre and inaccurate to prove anything conclusively.

In the lists of radiants I have included those of several very early or late *Perseids* whose real paths were determined from two or more observations, as the places afford a useful corroboration of the radiant positions of the shower at times when it has been but scantily recorded. The real paths and radiants of several hundreds of *Perseids* have been found for dates between August 1 and 14, but it has not been thought desirable to include these, as they were nearly all recorded on August 9, 10, or 11, when the situation of the radiant has been sufficiently well indicated from other observations. The letters "F" and "SS" refer to radiants deduced from duplicate observations of Fireballs and Shooting Stars respectively.

*Radiant Points of the Perseids observed by W. F. D.*

| | | α | δ | ℓ's |
|---|---|---|---|---|
| | | ° | ° | |
| 1877–8 | July 8–13 | 11 | +48 | 10 |
| 1876–7 | July 18 | 17 | +50 | 4 |
| 1900 | 19 | 17 | +50 | SS |
| 1887 | | 19 | +51 | 4 |
| 1901 | 21 | 23 | +52 | 5 |
| 1887 | 22 | 25 | +52 | 5 |
| 1887 | 23 | 25 | +52 | 4 |
| 1900 | | 24 | +52 | SS |
| 1900–1 | &c. 24 | 23 | +52 | 5 |
| 1900–1 | 25 | 22 | +52 | 5 |
| 1878 | 26 | 30 | +53 | 5 |
| 1887 | 27 | 29 | +54 | 5 |
| 1883 | 28 | 27 | +55 | 10 |
| 1887 | | 30 | +55 | 10 |
| 1878 | | 32 | +53 | 10 |
| 1879 | | 32 | +53 | 9 |
| 1887 | 29 | 31 | +54½ | 10 |
| 1878 | July 30 | 32 | +53 | 12 |
| 1898 | | 23 | +53 | SS |
| 1900 | | 30 | +52 | F |
| 1900 | | 31 | +54 | 10 |
| 1899 | July 29 –Aug. 2 | 34 | +54 | 8 |
| 1878 | July 31 | 32 | +53 | 20 |
| 1877 | | 35 | +54 | 11 |
| 1878 | Aug. 1 | 32 | +54 | 10 |
| 1887 | | 36 | +56 | 4 |
| 1897 | 1–2 | 36 | +56 | 13 |
| 1886 | 2 | 33 | +55 | 12 |
| 1888 | | 35 | +54 | 14 |
| 1881 | | 39 | +55 | 14 |
| 1877 | 3 | 39 | +55 | 7 |
| 1886 | 4 | 37 | +57 | 12 |
| 1877 | | 41 | +56 | 6 |

| | | α | δ | ↙'s | | | | α | δ | ↙'s |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ° | ° | | | | | ° | ° | |
| g. | 5 | 39 | +55 | 4 | 1882 | Aug. | 11 | 46 | +57 | 45 |
| | | 42 | +57 | 11 | 1886 | | | 47 | +57 | 15 |
| | 6 | 42 | +56 | 7 | 1887 | | | 45 | +57½ | 16 |
| | | 42 | +55 | 5 | 1895 | | | 44 | +58 | 7 |
| | | 40 | +55 | 6 | 1899 | | | 46 | +57 | 69 |
| | 7 | 40 | +56 | 7 | 1901 | | | 45 | +58 | 49 |
| | | 41 | +58 | 10 | 1898 | | | 46 | +58 | 106 |
| | | 41 | +55 | 14 | 1880 | | 12 | 48 | +57 | 19 |
| | | 43 | +56 | 5 | 1877 | | | 50 | +55 | 14 |
| | | 41 | +57 | 5 | 1899 | | | 48 | +5 | 43 |
| | 8 | 41 | +55 | 23 | 1893 | | | 48 | +58 | 7 |
| | | 41 | +56 | 12 | 1896 | | | 46 | +57 | 7 |
| | | 42 | +57 | 20 | 1880 | | 13 | 49½ | +57½ | 7 |
| | | 43 | +56 | 5 | 1888 | | | 52 | +57 | 13 |
| | 9 | 43 | +57 | 20 | 1885 | | | 51 | +58 | 6 |
| | | 44 | +55 | 71 | 1899 | | | 49 | +58 | 10 |
| | | 44 | +57 | 26 | 1893 | | | 48 | +58 | 8 |
| | | 46 | +58 | 38 | 1899 | | 14 | 50 | +56 | 12 |
| | 10 | 44 | +58½ | 252 | 1893 | | | 49 | +57 | 7 |
| | | 43 | +59 | 43 | 1887 | | | 53 | +57 | 8 |
| | | 43 | +58 | 285 | 1901 | | 15 | 51 | +58 | 6 |

| | | α | δ | ✓'s | |
|---|---|---|---|---|---|
| 1900 | July 24 | 25° + 52½° | 7 | W.E.B. |
| 1897 | 25 | 22 + 52 | 4 | H.C. |
| 1888 | 26 | 20 + 55 | 5 | D.B. |
| 1891 | 27 | 28 + 58½ | 7 | D.B. |
| 1898 | 29 | 31 + 54 | 5 | E.R.B. |
| 1897 | 30 | 37 + 53 | 4 | H.C. |
| 1900 | | 30 + 54 | 4 | E.M.A. |
| 1900 | July 30 –Aug. 1 | 33 + 54½ | 4 | J.H.B. |
| 1897 | July 30 –Aug. 2 | 27 + 53 | 24 | A.S.H. |
| 1897 | Aug. 1 | 33 + 56 | 4 | E.R.B. |
| 1899 | | 30 + 54½ | 5 | J.H.B. |
| 1895 | 2 | 35 + 55 | 16 | E.R.B. |
| 1897 | 3 | 32½ + 57 | 6 | W.E.B. |
| 1901 | | 35 + 56 | ... | E.M.A. |
| 1895 | 3–4 | 43 + 57 | 6 | W.H.M. |
| 1895 | 4 | 38 + 54 | 5 | E.R.B. |
| 1891 | | 39 + 57 | 11 | D.B. |
| 1893 | 5 | 39 + 54 | 4 | E.R.B. |
| 1896 | | 37 + 57 | 10 | W.H.M. |
| 1897 | 2–8 | 36 + 55 | 17 | A.S.H. |
| 1894 | 6 | 38 + 56 | 15 | E.R.B. |
| 1894 | | 45 + 57 | 8 | W.H.M. |
| 1894 | | 45 + 57 | 15 | H.C. |
| 1895 | 7 | 39 + 53 | 11 | E.R.B. |
| 1895 | | 40 + 56 | 7 | H.C. |
| 1900 | | 39 + 54 | 5 | J.H.B. |
| 1888 | 8 | 42 + 57½ | 21 | D.B. |
| 1893 | | 42 + 55 | 21 | E.R.B. |
| 1894 | | 47 + 57 | 4 | H.C. |
| 1893 | 9 | 44 + 55 | 9 | E.R.B. |
| 1894 | | 41¼ + 54½ | ... | C.D.P. |
| 1894 | | 42 + 56 | 17 | E.R.B. |
| 1893 | | 43 + 57 | 15 | D.B. |
| 1895 | | 43 + 57 | 23 | H.C. |
| 1896 | | 40 + 58 | 22 | W.H.M. |
| 1897 | | 42 + 56 | 21 | A.S.H. |
| 1897 | | 51 + 57 | 19 | A.S.H. |
| 1897 | | 45 + 57 | 17 | H.C. |
| 1897 | Aug. 9 | 43½ + 57½ | 71 | W.E.B. |
| 1898 | | 42 + 55½ | 10 | J.H.B. |
| 1899 | | 41 + 55½ | 8 | J.H.B. |
| 1899 | | 44½ + 57 | 7 | A.K. |
| 1901 | | 41 + 57 | ... | E.M.A. |
| 1901 | | 40 + 55 | 4 | J.H.B. |
| 1893 | 10 | 44 + 56 | 50 | E.R.B. |
| 1893 | | 45 + 57 | 17 | W.H.M. |
| 1893 | | 44 + 57½ | 100 | H.C. |
| 1894 | | 46 + 55 | ... | C.D.P. |
| 1894 | | 42 + 56 | 49 | E.R.B. |
| 1894 | | 45 + 51 | 15 | H.J.T. |
| 1896 | | 46 + 57 | 11 | J.A.H. |
| 1896 | | 43 + 58 | 20 | E.R.B. |
| 1896 | | 47½ + 58 | ... | D.B. |
| 1896 | | 47 + 58 | 30 | H.C. |
| 1898 | | 43 + 55½ | 16 | J.H.B. |
| 1898 | | 43 + 59 | 11 | H.C. |
| 1898 | | 45 + 55 | ... | T.E.R.P. |
| 1898 | | 43 + 53 | ... | H.J.T. |
| 1899 | | 43 + 56 | 12 | J.H.B. |
| 1899 | | 45 + 57 | 29 | A.K. |
| 1899 | | 45 + 58 | 54 | W.E.B. |
| 1899 | | 45 + 56 | 84 | E.M.A. |
| 1901 | | 43 + 56½ | 7 | J.H.B. |
| 1893 | 11 | 44½ + 57⅓ | 23 | W.D. |
| 1894 | | 44 + 65 | ... | C.D.P. |
| 1895 | | 45 + 56 | 13 | E.R.B. |
| 1895 | | 43 + 58 | ... | A.S.H. |
| 1895 | | 43½ + 58 | 72 | H.C. |
| 1896 | | 45 + 55 | 43 | E.R.B. |
| 1898 | | 45 + 58 | 40 | W.E.B. |
| 1898 | | 45 + 56 | 13 | J.H.B. |
| 1898 | | 49 + 58 | 13 | H.C. |
| 1898 | | 46 + 58 | ... | T.E.R.P. |
| 1898 | | 46 + 56 | 29 | H.J.T. |
| 1898 | | 45 + 58 | 30 | E.R.B. |
| 1899 | | 45 + 57 | 18 | J.H.B. |
| 1899 | | 45 + 57 | 8 | W.E.B. |

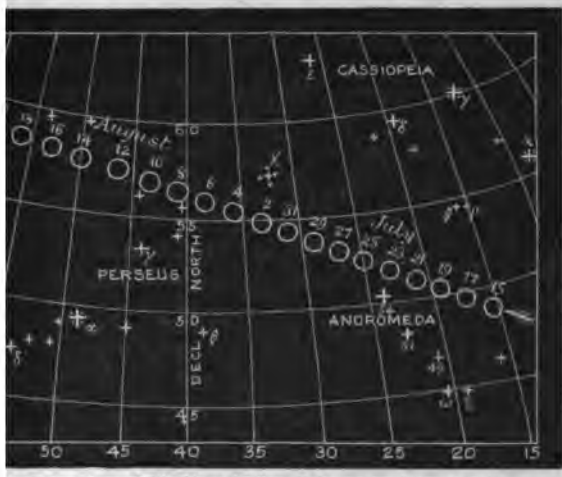
| α | δ | ↙'s | | | | α | δ | ↙'s | |
|---|---|---|---|---|---|---|---|---|---|
| ° | ° | | | | | ° | ° | | |
| 46 | + 57 | 17 | A.K. | 1891 | Aug. 14 | 56 | + 58½ | 8 | D.B. |
| 46½ | + 56 | 116 | E.M.A. | 1893 | | 49 | + 55 | 10 | E.R.B. |
| 43 | + 56½ | 6 | J.H.B. | 1893 | | 54 | + 59 | ... | H.C. |
| 46½ | + 57 | 14 | A.K. | 1895 | | 51 | + 58 | 6 | E.R.B. |
| 44⅓ | + 56½ | 9 | J.H.B. | 1896 | | 51 | + 59 | 24 | E.R.B. |
| 44 | + 56 | 26 | E.R.B. | 1899 | | 50 | + 58 | 5 | W.E.B. |
| 48 | + 57 | 6 | E.R.B. | 1900 | | 50 | + 56 | 5 | E.M.A. |
| 48 | + 60 | 30 | H.C. | 1891 | 15 | 58½ | + 59½ | 6 | D.B. |
| 46 | + 56⅓ | 10 | J.H.B. | 1893 | | 51½ | + 59 | ... | E.R.B. |
| 46 | + 57 | 6 | E.M.A. | 1893 | | 55 | + 57 | 5 | H.C. |
| 46½ | + 58 | 7 | A.K. | 1896 | | 50 | + 58 | 8 | W.H.M. |
| 48 | + 58 | 15 | W.E.B. | 1901 | | 51 | + 58 | 4 | A.K. |
| 48 | + 58 | 12 | A.K. | 1901 | | 48 | + 58 | 5 | J.H.B. |
| 47 | + 58 | 13 | A.K. | 1901 | | 53 | + 58 | ... | E.M.A. |
| 44 | + 57 | ... | E.M.A. | 1901 | | 54 | + 53 | F | A.S.H. |
| 51½ | + 56 | 17 | D.B. | 1901 | | 58 | + 58 | SS | A.S.H. |
| 51½ | + 56½ | 14 | H.C. | 1893 | 17 | 58 | + 62 | 7 | E.R.B. |
| 50 | + 59 | 10 | E.R.B. | 1893 | 18 | 54 | + 62 | ... | E.R.B. |
| 48 | + 55 | 15 | E.M.A. | 1893 | | 51 | + 56 | 11 | H.C. |
| 49 | + 57 | 5 | A.K. | 1901 | 19 | 53 | + 58 | ... | E.M.A. |
| 49 | + 58 | 10 | E.M.A. | 1893 | 21 | 55 | + 57 | 3 | ) |

| | | W.F.D. α ° δ ° | Radiants. | Other Observers α ° δ ° | Radiants. | Mean of all. α ° δ ° | Radiants. |
|---|---|---|---|---|---|---|---|
| July | 30 | 29·0 + 53·0 | 4 | 33·5 + 53·5 | 2 | 30·5 + 53·2 | 6 |
| | 31 | 33·7 + 53·7 | 3 | 33·0 + 54·5 | 1 | 33·5 + 53·9 | 4 |
| Aug. | 1 | 34·0 + 55·0 | 2 | 31·5 + 55·3 | 2 | 32·8 + 55·1 | 4 |
| | 2 | 35·7 + 54·7 | 3 | 35·0 + 55·0 | 1 | 35·5 + 54·7 | 4 |
| | 3 | 39·0 + 55·0 | 1 | 33·7 + 56·5 | 2 | 35·5 + 56·0 | 3 |
| | 4 | 39·0 + 56·5 | 2 | 38·5 + 55·5 | 2 | 38·8 + 56·0 | 4 |
| | 5 | 40·5 + 56·0 | 2 | 37·3 + 55·3 | 3 | 38·6 + 55·6 | 5 |
| | 6 | 41·3 + 55·3 | 3 | 42·7 + 56·7 | 3 | 42·0 + 56·0 | 6 |
| | 7 | 41·2 + 56·4 | 5 | 39·3 + 54·3 | 3 | 40·5 + 55·6 | 8 |
| | 8 | 41·7 + 56·0 | 4 | 43·7 + 56·5 | 3 | 42·6 + 56·2 | 7 |
| | 9 | 44·2 + 56·7 | 4 | 42·9 + 56·3 | 15 | 43·2 + 56·4 | 19 |
| | 10 | 43·9 + 57·3 | 15 | 44·4 + 56·3 | 19 | 44·2 + 56·8 | 34 |
| | 11 | 45·9 + 57·4 | 8 | 45·1 + 57·4 | 19 | 45·3 + 57·4 | 27 |
| | 12 | 48·0 + 56·8 | 5 | 46·5 + 57·5 | 10 | 47·0 + 57·3 | 15 |
| | 13 | 49·9 + 57·7 | 5 | 49·8 + 56·9 | 6 | 49·9 + 57·3 | 11 |
| | 14 | 50·7 + 56·7 | 3 | 52·0 + 57·9 | 8 | 51·6 + 57·5 | 11 |
| | 15 | 53·0 + 56·3 | 3 | 53·2 + 57·6 | 9 | 53·2 + 57·3 | 12 |
| | 16 | 53·0 + 57·5 | 4 | ... ... | ... | 53·0 + 57·5 | 4 |
| | 17 | 54·0 + 60·0 | 1 | 58·0 + 62·0 | 1 | 56·0 + 61·0 | 2 |
| | 18 | 55·0 + 59·0 | 1 | 52·5 + 59·0 | 2 | 53·3 + 59·0 | 3 |
| | 19 | 57·0 + 59·0 | 1 | 53·0 + 58·0 | 1 | 55·0 + 58·5 | 2 |
| | 20 | 57·0 + 58·5 | 1 | ... ... | ... | 57·0 + 58·5 | 1 |
| | 21 | 61·0 + 59·0 | 1 | 55·0 + 61·0 | 2 | 57·0 + 60·3 | 3 |
| | 22–3 | 59·0 + 59·0 | 1 | ... ... | ... | 59·0 + 59·0 | 1 |
| | | | 99 | | 123 | | 222 |

It will be seen from the mean positions of the radiant that the R.A. does not exhibit a regular diurnal increase, but that some marked irregularities are apparent. These are obviously due to errors of observation, which in certain cases have been large, and which, even in the most accurate results, have not been wholly eliminated. If the mean values for the radiant from all the observations are grouped into five-day periods the increase in the R.A. and N. Dec. becomes well defined, as follows :—

| Period. | Mean Place of Radiant. α ° δ ° | Number of Radiants. |
|---|---|---|
| July 18–22 | 20·5 + 51·0 | 6 |
| 23–27 | 24·7 + 53·3 | 13 |
| 28–Aug. 1 | 31·6 + 54·1 | 20 |
| Aug. 2–6 | 38·1 + 55·7 | 22 |

| Period. | Mean Place of Radiant. α ° | δ ° | Number of Radiants. |
|---|---|---|---|
| –11 | 43·2 | + 56·5 | 95 |
| 12–16 | 50·9 | + 57·4 | 53 |
| –22 | 56·2 | + 59·4 | 12 |




s of the Perseid Radiant Point, July 15 to August 20.

observers to place the centre too far south. It is often found that when a bright or fairly conspicuous star is situated near a radiant the latter is apt to be assigned nearer to the star than the truth requires. The ephemeris gives the R.A. of the radiant as less than that indicated in the similar table published in *Memoirs*, vol. liii., p. 210; but this is to be chiefly ascribed to the alteration rendered necessary by the absence of leap year in 1900, and moreover the present ephemeris has been independently formed from more extensive materials than could possibly be employed in the previous case:

*Ephemeris of the Perseid Radiant Point.*

| | α | δ | | α | δ |
|---|---|---|---|---|---|
| | ° | ° | | ° | ° |
| July 15 | 15·3 | +48·9 | Aug. 3 | 35·1 | +55·3 |
| 16 | 16·2 | +49·3 | 4 | 36·4 | +55·5 |
| 17 | 17·1 | +49·7 | 5 | 37·6 | +55·7 |
| 18 | 18·0 | +50·1 | 6 | 38·9 | +56·0 |
| 19 | 18·9 | +50·5 | 7 | 40·2 | +56·2 |
| 20 | 19·8 | +50·8 | 8 | 41·5 | +56·5 |
| 21 | 20·8 | +51·1 | 9 | 42·9 | +56·7 |
| 22 | 21·8 | +51·5 | 10 | 44·3 | +56·9 |
| 23 | 22·8 | +51·8 | 11 | 45·7 | +57·1 |
| 24 | 23·8 | +52·2 | 12 | 47·1 | +57·3 |
| 25 | 24·9 | +52·5 | 13 | 48·5 | +57·5 |
| 26 | 26·0 | +52·8 | 14 | 50·0 | +57·7 |
| 27 | 27·1 | +53·2 | 15 | 51·4 | +57·8 |
| 28 | 28·2 | +53·5 | 16 | 52·9 | +58·0 |
| 29 | 29·3 | +53·8 | 17 | 54·4 | +58·2 |
| 30 | 30·5 | +54·1 | 18 | 55·9 | +58·4 |
| 31 | 31·6 | +54·4 | 19 | 57·4 | +58·5 |
| Aug. 1 | 32·7 | +54·7 | 20 | 58·9 | +58·7 |
| 2 | 33·9 | +55·0 | | | |

Probably the display commences in a very feeble form before July 15, and is continued to a later date than August 20. In the third week of July the shower is, however, very liable to be confused with a radiant of swift, streak-leaving meteors directed from near $\gamma$ *Andromedæ* (24°+43°); and in the third week of August it becomes apparently blended with a shower of *Camelopardids* (60°+59°).

*Bishopston, Bristol:* 1901 *November* 10.

*te on a Large Fireball.* By W. F. Denning.

$5^m$, soon after dark on the very clear frosty e
er 4 last, a fireball of exceptional brilliand
om various parts of the country. It gave a f
ensity, illuminating the English Channel and
with a light stronger than that of the full
l had a bluish-green head, and along the
ction of its flight it projected a train or str
material, which remained visible to the eye
to five minutes according to the various estim
ferent persons.
ition of the train amongst the stars was ca
veral observers. Admiral Maclear at Chiddi
nd it to extend from $290\frac{1}{2}° + 11\frac{1}{2}°$ to $295\frac{1}{2}° + 5\frac{1}{2}$
ldham, of Tunbridge Wells, Kent, says it was 7
laced midway between *o Herculis* and *χ Aquil*
t line with these stars and the planet *Venus*.
A. Ellison, of Dublin, saw the fireball as it
s, low in the S.E., and the place of the lingerin
$° - 10°$ to $16° - 16°$. From these and some add
which I have compared the real path appears t
ows :

at beginning ... 91 miles over English Ch

## *Observation of the Leonid Meteors of* 1901, *made at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

On the nights of November 14–15 and November 15–16 watch for meteors was maintained by four observers from midnight to 5 A.M., with the following results :—

| Date. 1901. | Length of Watch. | Total Number of Meteors. | Number of Leonids. | Number of Leonids per Hour. |
|---|---|---|---|---|
| November 14–15 | 5 hours | 66 | 46 | 9·2 |
| „ 15–16 | 5 „ | 43 | 43 | 8·6 |

The night of November 13–14 was overcast and rainy, November 14–15 was cloudless and bright, and November 15–16 was partially foggy and cloudy. The number of Leonids observed each year since 1887 is given in the *Monthly Notices*, vol. lx., p. 163. Reference to this table shows that a much larger number of meteors was observed this year, though it should be remembered that the weather was rather more favourable this year than in most of the preceding years. These observations afford some evidence that this year the Earth passed through part of the meteor swarm denser than the average, and probably denser than in any of the years 1896 to 1900.

*Royal Observatory, Greenwich:*
1901 *December* 19.

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## *The Leonids*, 1901. *Observations made at the Radcliffe Observatory, Oxford.*

(*Communicated by the Radcliffe Observer.*)

During the night of November 13 the sky was occasionally watched for a possible shower of *Leonids*, but few meteors were seen.

On November 15 from $12^h$ to $15^h$ G.M.T. the sky was generally clear, but high driving fog passed across at times. Mr. McClellan, who watched at frequent intervals, saw only two meteors, viz. :—

| G.M.T. h m | |
|---|---|
| 14 40 | 1st magnitude; Leonid with train from $\mu$ Leonis towards 38 Lyncis. |
| 14 42 | Sporadic. |

watch for meteors was commenced on the night of
, just before $13^h$ G.M.T., by Mr. Robinson. Except
t break ($15^h\ 11^m$ to $15^h\ 23^m$ G.M.T.) the watch was
ntil $18^h$ G.M.T. The observer remarks :—
he constellation of *Leo* was only dimly visible in
which, however, became less dense later on. The
dless throughout, and stars to the 5th or 6th magni-
be easily seen, except for small altitudes. About
and a little earlier, a long band of diffused light
n width was observed stretching from the eastern
rds and slightly beyond the six stars forming the
he phenomenon—probably that of the zodiacal light
re conspicuous later on, or just before dawn. Its
lay along the ecliptic, enveloping *Spica* in E.S.E.,
onstellations of *Virgo* and *Leo*, the brightest and
tion being over the horizon.
*ids* presented the characteristic features observed in
, being swift, and generally leaving luminous trails,
o or three seconds. The approximate G.M.T. for
was recorded, and notes of magnitude, direction,
trails of the more important were taken. When
had fully identified the brighter stars in the
od of *Leo*, several of the more luminous tracks were
r this purpose a wand, held and adjusted across
treak, enabled a reliable observation to be made of
of the flight of the meteor. Seven observed in this
adiant of small area near

| No. | G.M.T. h m | |
|---|---|---|
| 8 | 13 24 | S.E. Sickle; streak. |
| 9 | 13 25 | Leo towards zenith; very swift. |
| 10 | 13 26 | Short; in Gemini. |
| 11 | 13 30 | Short; possibly Leonid. |
| 12 | 13 30 | Near Pollux, below Pleiades; long bright trail. |
| 13 | 13 33 | 1st mag.; track recorded on chart (A). |
| 14 | 13 38 | N. and N.W.; swift; 4th mag. |
| 15 | 13 50 | Short; low down N.E.; small. |
| 16 | 13 51 | From zenith; sporadic. |
| 17 | 13 55 | Ursæ Maj. to zenith; 3rd mag. |
| 18 | 14 0 | Above Leo; sporadic; 4th mag. |
| 19 | 14 4 | Through Gemini; streak; 3rd mag. |
| 20 | 14 4 | Below Sirius; swift; streak; 1st mag. |
| 21 | 14 10 | Sickle through zenith; long streak; 1st mag. |
| 22 | 14 17 | Near Sirius; sporadic; short; 4th mag. |
| 23 | 14 19 | Between $\zeta$ and $\mu$ Leonis; short; 4th mag. |
| 24 | 14 21 | Below Sickle; sporadic. |
| 25 | 14 21 | Above Sickle; sporadic. |
| 26 | 14 24 | Streak; 3rd mag.; path recorded (B) on chart. |
| 27 | 14 30 | N.E. |
| 28 | 14 36 | Through pointers of Ursæ Maj. to below pole; streak; bright; swift. |
| 29 | 14 38 | Through or near Aldebaran. |
| 30 | 14 39 | Passed between $\beta$ and $\gamma$ Ursæ Maj.; Leonid. |
| 31 | 14 46 | Ursæ Maj., low; doubtful Leonid. |
| 32 | 14 49 | Slow sporadic from between $\delta$ and $\beta$ Leonis to below Regulus; streak; 4th mag. |
| 33 | 14 50 | Zenith towards Coma Berenices; 3rd mag. |
| 34 | 14 54 | Castor and Pollux to Sickle; sporadic. |
| 35 | 14 55 | Præsepe to $\gamma$ Leonis; sporadic. |
| 36 | 14 58 | Sickle to between $\theta$ and $\alpha$ Hydræ. |
| 37 | 14 59 | Bright, from zenith. |
| 38 | 15 2 | Near $\delta$ Leonis, from Sickle. |
| 39 | 15 6 | Just above $\lambda$ Ursæ Maj. to $\delta$ Ursæ Min. Direction same as **A** in chart. |
| | 15 11 to 15 24 | Break in watch. |
| 40 | 15 26 | Around Leo; not Leonids. |
| 41 | 15 26½ | |
| 42 | 15 27 | |

Canes Venat., through Coma Berenices ; sporadic.

Leonid ; through $\alpha$ Canum Venat., below $\eta$ Ursæ Maj. ;

Leonid; slightly above $\theta$ Hydræ, to Argo ; streak.

From midway between Regulus and $\theta$ Hydræ, to east of streak.

Passed between $\beta$ and $\gamma$ Ursæ Maj. ; Leonid.

Towards Cassiopeia ; swift ; 1st mag.

$\lambda$ and $\mu$ Ursæ Maj. ; Leonid ; streak.

Below Leo ; Leonid ; streak.

Coma Berenices and $\beta$ Leonis ; streak.

Sporadic ; west of Leo.

Leonid ; between Regulus and $o$ Leonis.

Towards S.E., from the western sky.

Leo to east of $\alpha$ Hydræ ; very swift ; no trail.

Bright ; streak ; path recorded on chart (C).

Probably Leonid.

N.E. ; swift.

Through Procyon ; bright streak ; Leonid.

Leonid ; faint.

Sporadic.

Through $\iota$ and $\kappa$ Ursæ Maj. ; bright.

ENE. direction ; bright

| No. | G.M.T. h | m | |
|---|---|---|---|
| 82 | 16 | 56 | Streak; Radiant to east. |
| 83 | 16 | 56 | Streak; charted (D). |
| 84 | 17 | 0 | Leonid; towards $\delta$ or $\beta$ Leonis. |
| 85 | 17 | 2 | Low E.S.E.; possibly Leonid. |
| 86 | 17 | 5 | No streak; in Leo. |
| 87 | 17 | 5 | No streak; in Leo. |
| 88 | 17 | 6 | Short; Leo; no streak. |
| 89 | 17 | 12 | Short; in Leo. |
| 90 | 17 | 14 | East of Regulus; eastwards. |
| 91 | 17 | 15 | Below Sickle; sporadic. |
| 92 | 17 | 19 | Leonid; Virgo. |
| 93 | 17 | 20 | Sporadic; Hydra. |
| 94 | 17 | 21 | Streak. |
| 95 | 17 | 21 | Bright; rapid; low down. |
| 96 | 17 | 22 | Streak from Hydra; sporadic. |
| 97 | 17 | 23 | Leonid; near Regulus; streak. |
| 98 | 17 | 29 | Streak; Leonid; between Hydra and Præsepe. |
| 99 | 17 | 33 | Leonid; below Arcturus. |
| 100 | 17 | 34 | Bright streak; charted (E). |
| 101 | 17 | 44 | To zenith. |
| 102 | 17 | 45 | To east. |
| 103 | 17 | 45 | Streak to N.E. |
| 104 | 17 | 53 | Streak; Leonid. |
| 105 | 17 | 53 | Streak; Leonid; charted (F). |
| 106 | 17 | 59½ | Bright streak; charted (G). |
| | 18 | 0 | Watch relinquished; twilight increasing. |

The positions of the seven charted paths were as follows :

*Epoch* 1880.

| | | R.A. h | m | Dec. ° | ′ | | R.A. h | m | Dec. ° | ′ |
|---|---|---|---|---|---|---|---|---|---|---|
| (A) | From | 9 | 59 | +32 | 30 | To | 10 | 11 | +50 | 0 |
| (B) | ,, | 9 | 6 | +13 | 0 | ,, | 8 | 26 | + 6 | 0 |
| (C) | ,, | 10 | 55 | +30 | 15 | ,, | 12 | 0 | +39 | 30 |
| (D) | ,, | 9 | 53 | +17 | 0 | ,, | 9 | 53 | + 5 | 0 |
| (E) | ,, | 9 | 10 | +16 | 45 | ,, | 8 | 0 | + 7 | 30 |
| (F) | ,, | 9 | 37 | +18 | 0 | ,, | 9 | 0 | + 5 | 0 |
| (G) | ,, | 10 | 24 | +23 | 0 | ,, | 12 | 1 | +20 | 0 |

*Radcliffe Observatory, Oxford:*
1901 *December* 11.

## *Apparent Paucity of the Leonid Stream.*

By the Rev. S. J. Johnson.

rning of November 14 was densely clouded; t
ear and frosty, giving opportunity for obser
the Moon was absent. A little watching soon s
wer, though existing, was very feeble at the tir
to that of the *Perseids* last August. It was
tensity to that which I witnessed on the morn
nber 14. From $2^h$ to $2^h$ $45^m$ (morn.) on the
ree *Leonids*, the largest being at $2^h$ $42\frac{1}{2}^m$, abo
*ulus*; also one non-*Leonid* across $\eta$.
to $5^h$ (morn.) five *Leonids*, two of which equal
ude stars, one at $4^h7^m$, just beneath 46 *Leon.*
rom about $161°+34°$ to $163°+36°$; the other at
ut 3° left of *Arcturus*. From $215°+21°$ to $220°$
morning of the 16th the radiant was slightly
ll, the Earth could only have been passing th
tions of the shower. From $4^h$ $55^m$ to $6^h$ A.M. I r
*s*, all within the first thirty-five minutes.
$5\frac{3}{4}^m$ (morn.) nearly equal *Jupiter*, green train.
*eonis*. $173°+16°$ to $180°+13°$.
$^m$ magnitude 1 train. From a point 7° above $\delta$
ds 12 *Coma Beren.* $168°+27°$ to $180°+28°$.
$3\frac{3}{4}^m$ equal *Jupiter*. Between $\epsilon$ *Virginis* and *Ar*
$0\ 207°+11°$

watched from the neighbourhood of Dalston, told me that he saw no meteors at all.

It is evident from the reports to hand that there has not been any display this year of any consequence, though a few observers have been able to see a small number of meteors. It seems fairly certain that we are not likely to witness in this decade anything at all approaching the wonderful displays of 1833 and 1866, which have caused such an interest to attach itself to this swarm, but perhaps those of us who survive for another thirty years may be more fortunate.

*Markree Observatory:* 1901 *December* 10.



# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. LXII. JANUARY 10, 1902. No. 3


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Charles Tallent Spencer, A.M.Inst.C.E., La Quinta, Lyon Road, Harrow; and
Rev. Charles Lakeman Tweedale, M.A., The Vicarage, Weston, near Ottley,

were balloted for and duly elected Fellows of the Society.

wing Candidates were proposed for election as
e Society, the names of the proposers from personal
ing appended :—

ler Lawrence Child, Vernham, Merton Hall Road,
ledon (proposed by Col. E. E. Markwick) ;
as Solá, S. Felipe, 29 S. Gervasio, Barcelona, Spain
sed by A. Stanley Williams) ;
n Horsley Haslam, M.A. Cantab., Vicar of St.
r's, Denmark Park, S.E. (proposed by D. G.
on) ;
Lunt, B.Sc., F.I.C., Royal Observatory, Cape of
Hope (proposed by Sir David Gill) ; and
andra Ray, M.A., Professor of Physical Science,
k, Bengal, India (proposed by U. Chandra Ghosh).

---

ix presents were announced as having been received
meeting, including amongst others :—

)pere, Edizio Nazionale, vol. 11, presented by the
rnment ; 22 Charts of the international photo-
of the heavens, presented by the Paris Observa-
wood Medallion of Sir Wm. Herschel by Flaxman,
Sir W. J. Herschel ; Photograph from a portrait of
stermans, presented by Sir W. Huggins.

at Kalianpur," he writes, "is considerably south." Shortly after the issue of General Walker's paper in 1896, Sir David Gill's work on the Geodetic Survey of South Africa was published, in which the adoption of "groups" of astronomical stations was strongly recommended. In consequence of the opinions expressed by these eminent writers, and in full accord with their views, we decided in 1898 to determine the actual effect of local attraction at Kalianpur by means of a complete "group."

2. By the spring of 1899 astronomical observations for both latitude and azimuth had been taken at Kalianpur, and at eight adjacent stations, four being situated at an average distance of nine miles and four at an average distance of thirty-five miles from Kalianpur. A discussion of the results of the observations showed that local attraction was causing a *northerly* deflection at Kalianpur. This unexpected issue created a dilemma; either General Walker had been mistaken in advocating "groups," or his assumption of a southerly deflection at Kalianpur had been incorrect.

3. A classification of the results of the latitude observations discloses two remarkable facts: First, that two-thirds of the southerly deflections observed in India are situated within a narrow zone, running from east to west between the parallels of 24° and 26° approximately. Second, that large northerly deflections prevail from east to west between the parallels of 24° and 18° approximately.

4. I attached at first great significance to the fact that the parallel of 24°, along which approximately the direction of the deflection changes sign, happens to be the parallel of Kalianpur, the station of reference of the survey. I calculated the respective effects of the Himalayan mass and of the deficiency of matter in the Indian Ocean at twelve different stations, and found that if the Himalayas exercised their normal attraction on the plumb-line throughout India, and the deficiency of matter in the Indian Ocean exerted a northerly repulsive force, the sign of the deflections would change along the parallel of 24°. But this explanation of the observed phenomena could not be maintained; the results of the longitude arcs observed across India from coast to coast showed that the deficiency of matter in the Indian Ocean was wholly compensated by submarine strata of excessive density. If the effect of the Indian Ocean is compensated in the prime vertical it must be compensated also in the meridian.

5. After this first failure I undertook an investigation to see whether the change in the sign of the deflection could be due to errors of the ellipsoid of reference; but, though such errors would produce a change of sign along the parallel of the station of origin, the investigation showed that no considerable modification of the Clarke spheroid was possible.

6. The difficulty with which we are now confronted is this: it is clear that Himalayan attraction is *not* compensated so completely as Archdeacon Pratt believed, large deflections of

having been met with in sub-Himalayan regions
rchdeacon's death; but if Himalayan attraction
he plumb-lines in India, the deflections north of
should be more northerly than the deflection at
nd the deflections south of latitude 24° should be
y. As has been explained above the observed
rth of Kalianpur are southerly, and the observed
uth of Kalianpur are northerly. (The deflections
arded as accidental or as due to "local attraction.")
strate the observed phenomena the following table
ich typical stations only have been entered. The
7° 30′ has been selected, but the same alternation
served on other meridians.

TABLE I.

| Lat. | Observed deflection. | |
|---|---|---|
| ... 30° 19′ | −3.8″ | Himalayan influences. |
| ... 29 31 | − 7 | |
| ... 27 51 | 0 | Belt of southerly deflections. |
| ... 24 38 | + 1 | |
| ... 24 7 | station of reference. | |
| ... 23 8 | − 5 | Belt of large northerly deflections. |
| ... 20 44 | − 8 | |
| ... 18 3 | − 3 | |

vicinity of a station situated even at their foot. In the *Philosophical Transactions of the Royal Society*, vol. 186, p. 803, General Walker wrote:—"It is thus evident that the effect of the attraction of mountain masses on the plumb-line, which may be very large in the immediate vicinity of the mountains, will be reduced at a distance in greater proportion than is assigned by an incomplete application of the law of gravitation, because of the deficiency in the density of the strata under the mountains, which has not hitherto been allowed for. Eventually a point must be reached at which the positive attraction of the matter above will be cancelled by the negative attraction of the deficiency below, and then the mountain masses will have no influence on the plumb-line."

When, however, one comes to apply in practice the theory propounded in this extract, one finds that if the Himalayas are compensated by underlying deficiencies of matter, the compensating cause will affect the plumb-lines at *both near and distant* stations.

9. I have calculated the effect of the attraction of the Himalayan mass at five stations on the meridian of 77° 30′, viz. Dehra Dun, Kaliana, Kalianpur, Damargida, and Cape Comorin, and have interpolated its effects at other stations from a plotted curve. The results are as follows :—

TABLE II.

| Station. | Lat. | Calculated deflection due to— | | | Differential deflection from Kalianpur. |
|---|---|---|---|---|---|
| | | Himalayan ranges. | Tibetan Plateau. | Total. | |
| | ° ′ | ″ | ″ | ″ | ″ |
| Dehra Dun ... | 30 19 | 19 | 53 | 72 | −54 |
| Kaliana ... | 29 31 | 2 | 34 | 36 | −18 |
| Noh ... | 27 51 | 1 | 27 | 28 | −10 |
| Daisdhari ... | 24 38 | | 20 | 20 | − 2 |
| Kalianpur ... | 24 7 | | 18 | 18 | ... |
| Ladi ... | 23 8 | | 16 | 16 | + 2 |
| Badgaon ... | 20 44 | | 13 | 13 | + 5 |
| Damargida | 18 3 | | 10 | 10 | + 8 |
| Cape Comorin | 8 9 | | 3 | 3 | +15 |

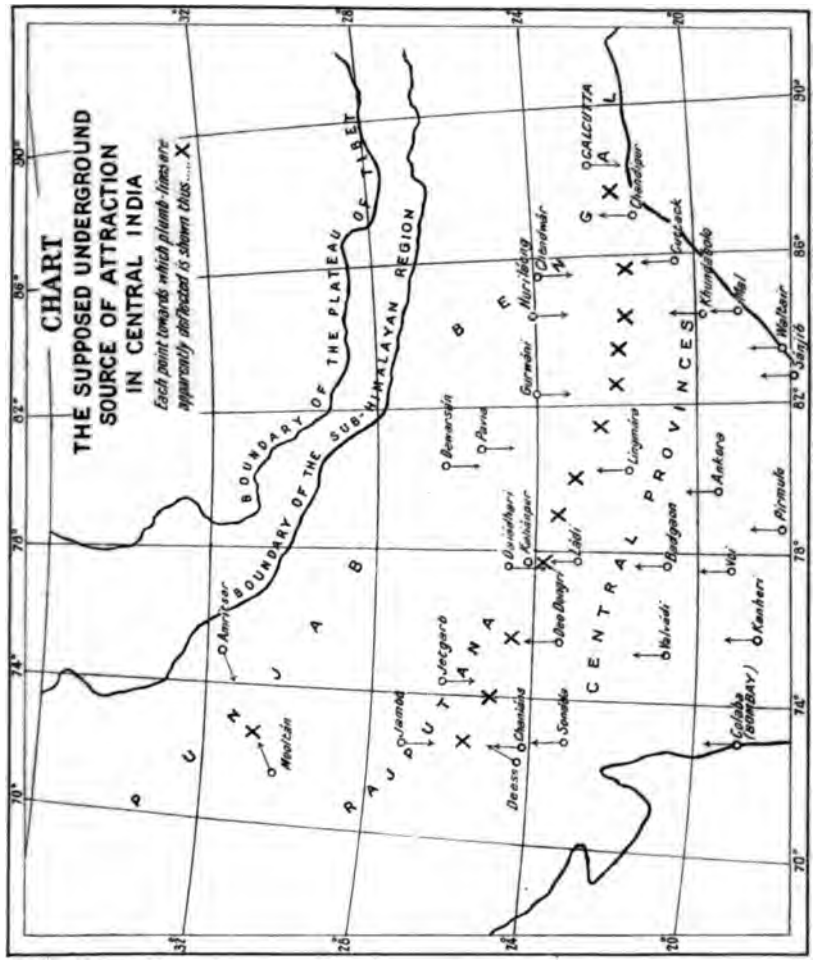
10. In the following table the results of observation and calculation are compared :—

TABLE III.

| Station. | Differential Deflections. | | Discrepancy. =O−C. |
|---|---|---|---|
| | By Observation. =O. | By Calculation. =C. | |
| Dehra Dun ... | −38 | −54 | −16 |
| Kaliana ... | − 7 | −18 | −11 |
| Noh ... ... | 0 | −10 | −10 |

| | Differential Deflections. | | |
|---|---|---|---|
| | By Observation. =O. | By Calculation. =C. | Discrepancy. =C−O. |
| i ... | + 1 | − 2 | − 3 |
| r ... | ... | ... | ... |
| . ... | − 5 | + 2 | + 7 |
| ... | − 8 | + 5 | +13 |
| la ... | − 3 | + 8 | +11 |
| norin ... | + 2 | +15 | +13 |

ations immediately north of Kalianpur the deflection northerly, but the observed deflection southerly; at ediately south the observed deflection is northerly etical deflection southerly. There appears therefore dden cause which is tending to reduce the northerly northern stations and to increase the northerly southern stations; and I have been led to infer of an underground chain of excessive density that ral India for 1,000 miles, and which underlies ndla, Bhopal, and Jodhpore. The attraction of this ons situated to the north of it is opposed to Hima- ion; at stations situated to the south of it the two t in concert. The chain imposes a wave on the alayan attraction, and masks the true effects of the e hypothesis of the chain is correct, then the change the deflections that occurs approximately along the


CHART
THE SUPPOSED UNDERGROUND SOURCE OF ATTRACTION IN CENTRAL INDIA
Each point towards which plumb-lines are apparently deflected is shown thus.....X
BOUNDARY OF THE PLATEAU OF TIBET
BOUNDARY OF THE SUB-HIMALAYAN REGION
CENTRAL PROVINCES
BENGAL
PUNJAB
RAJPUTANA
Amritsar
Mooltan
Jeypore
Deesa
Chanda
Sironcha
Delhi
Rewarpur
Pavia
Gurmahi
Nurrinjong
Chandmar
Lingmara
Badgaon
Antara
Pirmuk
Kanheri
Golaba (BOMBAY)
CALCUTTA
Chandpur
Futtack
Khunjeeta
Puri
Jangra
Nolsar



can be traced from longitude 88° to longitude 73°, and runs from E.S.E. to W.N.W., *in apparent parallelism with the Himalayas.* In the Punjab, to the *west* of the Himalaya Mountains, the longitude arc, Amritsar—Mooltan, reproduces the same extraordinary result as the latitude observations have given in Bengal to the *south* of the Himalayas. Just as the plumb-lines on all meridians from 88° to 73° seem to be deflected inwards towards one line, so are the plumb-lines at Amritsar and Mooltan deflected inwards towards the low-lying alluvium and away from the mountain masses. A chart is attached to illustrate the course of the chain (Plate 6).

15. It cannot be assumed that the discrepancies shown in Table III. are the actual effects of the chain. It is possible that the Himalayan mass is compensated to some extent by subjacent deficiencies of matter. The numerical discrepancies in Table III. have been derived without any such compensation being assumed.

16. In the following table are shown the discrepancies that occur between theory and observation if we assume the attraction of the Himalayas to be compensated to the extent of one-third, one-half, and two-thirds its normal force respectively. As Kalianpur is under the influence of the supposed chain, Cape Comorin has been now taken as the station of reference.

TABLE IV.

| Station. | Discrepancies between theory and observation, the attraction of the Himalayan ranges and Tibetan plateau being assumed compensated to the extent of | | |
|---|---|---|---|
| | ⅓ | ½ | ⅔ |
| Dehra Dun ... ... ... | − 6 | + 6 | +17 |
| Kaliana ... ... ... | −13 | − 7 | − 2 |
| Noh ... ... ... ... | −15 | −10 | − 6 |
| Daisdhari ... ... ... | −10 | − 7 | − 5 |
| Kalianpur ... ... ... | − 8 | − 5 | − 3 |
| Ladi ... ... ... ... | − 2 | + 1 | + 3 |
| Badgaon ... ... ... | + 3 | + 5 | + 7 |
| Damargida ... ... ... | 0 | + 2 | + 3 |
| Cape Comorin ... ... ... | — | — | — |

It will be seen that discrepancies of 13″ and 15″ continue to appear, if a theory of a one-third compensation be adopted. The theory of a two-thirds compensation renders the effects of the chain approximately equal and opposite, but introduces a discrepancy of 17″ at Dehra Dun.

17. In the following table are shown the discrepancies that occur between theory and observation if we assume the attraction of the successive Himalayan ranges to be uncompensated and that of the Tibetan plateau to be compensated to the extent of one-third, one-half, and two-thirds its normal force respectively :—

TABLE V.

| | Discrepancies between theory and observation, the attraction of the Tibetan plateau being assumed compensated to the extent of | | |
|---|---|---|---|
| | ⅓ | ½ | ⅔ |
| ... ... ... | −12 | − 4 | +4 |
| ... ... ... | −14 | − 9 | −4 |
| ... ... ... | −15 | −11 | −8 |
| ... ... ... | −10 | − 8 | −5 |
| ... ... ... | − 8 | − 6 | −3 |
| ... ... ... | − 2 | + 1 | +3 |
| ... ... ... | + 4 | + 5 | +7 |
| ... ... ... | + 1 | + 2 | +3 |
| rin ... ... ... | — | — | — |

sis that the attraction of the outer Himalayan compensated, and that that of the Tibetan plateau ed to the extent of two-thirds its normal force, discrepancies and renders the effects of the chain stations to the north and south of it equal and makes the crest of the chain cut the meridian of titude 23° 30′, and it attributes to the chain a ect of 8″ at 200 miles north and south of its crest.* attempt to disentangle the effects of the chain from Himalayas, and to obtain a definite numerical idea,

to be unity without affecting the generality of the investigation. Let $f(x, y)$ be its potential energy when at the point $(x, y)$, so that its total energy may be taken to be

$$\tfrac{1}{2}\left(\frac{dx}{dt}\right)^2 + \tfrac{1}{2}\left(\frac{dy}{dt}\right)^2 + f(x, y).$$

The differential equations of motion of the particle form a system of the fourth order, and their general solution consequently involves four arbitrary constants. One of these constants is, however, merely the constant additive to $t$, which determines the epoch in the orbit, and so there are only $\infty^3$ really distinct orbits. This triple infinity of orbits can be arranged in sets, each containing a double infinity of orbits, by associating together those orbits which correspond to the same value of the constant of energy. We shall consider one such set of $\infty^2$ orbits, characterised by the condition that the constant of energy has the value $h$, so that

$$\tfrac{1}{2}\left(\frac{dx}{dt}\right)^2 + \tfrac{1}{2}\left(\frac{dy}{dt}\right)^2 = h - f(x, y).$$

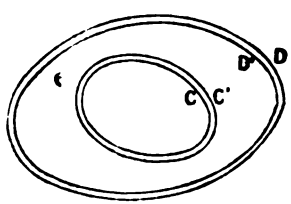
These orbits are defined analytically by means of the principle of least action; namely, that the orbit between two given points $(x_0, y_0)$ and $(x_1, y_1)$ is such as to make the value of the expression

$$\int \{h - f(x, y)\}^{\frac{1}{2}} \{(dx)^2 + (dy)^2\}^{\frac{1}{2}}$$

stationary as compared with other curves joining the given terminal points $(x_0, y_0)$ and $(x_1, y_1)$. Our attention will be directed particularly to those orbits which are *periodic*, i.e. which are in the form of closed curves.

1°. *A criterion which may be used in the discovery of periodic orbits.*

Consider any simple closed curve $C$ in the plane of $x\,y$; and let another simple closed curve $C'$ be drawn, enclosing $C$ and




differing only slightly from it. We may regard C′ as defined by an equation of the form

$$\delta p = \phi(\gamma)$$

s the normal distance between the curves C a
inclination of this normal distance to the axi
the value of the integral

$$\int \{h - f(x, y)\}^{\frac{1}{2}} \{(dx)^2 + (dy)^2\}^{\frac{1}{2}}$$

ntegration is taken round the curve C, and if
value of the same integral when the integrat
the curve C′ (so that the symbol $\delta$ denotes an
ed in passing from C to C′), we have

$$x)^2 + (dy)^2\}^{\frac{1}{2}} \delta\{h - f(x, y)\}^{\frac{1}{2}} + \int \{h - f(x, y)\}^{\frac{1}{2}}$$

$$\delta\{(dx)^2 + (d$$

$$f(x, y)\}^{\frac{1}{2}} = -\tfrac{1}{2}\{h - f(x, y)\}^{-\frac{1}{2}} \left(\frac{\partial f}{\partial x}\delta x + \frac{\partial f}{\partial y}\delta y\right)$$

$$= -\tfrac{1}{2}\{h - f(x, y)\}^{-\frac{1}{2}} \left(\frac{\partial f}{\partial x}\cos\gamma + \frac{\partial f}{\partial y}\sin\gamma\right.$$

$$\delta x = \delta p \cos\gamma, \qquad \delta y = \delta p \sin\gamma.$$

$$\delta\{(dx)^2 + (dy)^2\}^{\frac{1}{2}} = \delta p \,.\, d\gamma$$

$$= \frac{\delta p}{\quad}\{(dx)^2 + (dy)^2\}^{\frac{1}{2}},$$

is negative. Then, in the same way, it can be shown that the quantity I is increased when any simple closed curve $D'$, enclosed by D and adjacent to D, is taken instead of D as the path of integration.

When, therefore, we consider the aggregate of all simple closed curves situated in the ring-shaped space bounded by $C$ and $D$—which is assumed to contain no singularity of the function $f(x, y)$—it is clear that the curve which furnishes the greatest value of I cannot be $C$ or $D$, and cannot coincide with $C$ or $D$ for any part of its length. There exists, therefore, among the simple closed curves of this aggregate one or more curves K for which the value of I is greater than for all the other curves of the aggregate. Since K does not coincide with $C$ or $D$ along any part of its length, it follows that the curves adjacent to $K$ are all members of the aggregate in question, and hence that the curve K furnishes a stationary value of I as compared with all the curves adjacent to it. The curve $K$ is therefore an orbit in the dynamical problem. We have thus arrived at the theorem

I. *If one closed curve be enclosed by another closed curve, and if the quantity*

$$\frac{h-f(x, y)}{\rho}-\tfrac{1}{2}\cos\gamma\frac{\partial f}{\partial x}-\tfrac{1}{2}\sin\gamma\frac{\partial f}{\partial y}$$

*be positive at all points of the inner curve and negative at all points of the outer curve, then in the ring-shaped space between the two curves there exists a periodic orbit of the dynamical problem.*

This result may be regarded as an analogue, in the theory of periodic orbits, of those theorems in the theory of equations which furnish the position of the roots by criteria depending on the sign of expressions connected with the equation. As the quantity

$$\frac{h-f(x, y)}{\rho}-\tfrac{1}{2}\cos\gamma\frac{\partial f}{\partial x}-\tfrac{1}{2}\sin\gamma\frac{\partial f}{\partial y}$$

can be immediately calculated for every point on the curves C and D, depending as it does only on the potential-energy function and the curves themselves, this result furnishes a means of detecting the presence of periodic orbits. Thus if we take, for example, the potential-energy function to be that due to two Newtonian centres of force of intensity 50 at the points (1, 0) and (− 1, 0), so that

$$f(x, y)=-\frac{50}{\{(x-1)^2+y^2\}^{\frac{1}{2}}}-\frac{50}{\{(x+1)^2+y^2\}^{\frac{1}{2}}},$$

and take $h=-\frac{1}{2}$, and choose the curves C and D to be circles whose centre is at the origin and whose radii are 80 and 120 respectively, it is easily found that the conditions mentioned above are satisfied, and that the existence of a periodic orbit in the ring-shaped space between these circles can be inferred.

*ntegral connected with periodic orbits.*

l now suppose that the field of force in the dyna-
em considered is due to several centres of force,
ccording to the Newtonian law of the inverse square
nce. We shall consider a periodic orbit, enclosing
r of these centres of force, and shall establish the
eorem :

*gral*

$$\frac{1}{2\pi}\iint\left[\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\log\{h-f(x,y)\}\right]dxdy,$$

*ntegration is taken over the interior of any periodic*
*al to the number of centres of force enclosed by the orbit,*
*by two.*

e quantity $\{h-f(x, y)\}$ is infinite at each centre of
ecessary to discuss the legitimacy of integrating over
ich contains centres of force.

then that each centre of force is surrounded by a
having its centre at the centre of force. Let the
it be denoted by $C$, and let these small circles be
$\gamma, \gamma', \gamma'', \ldots$ Then if $S$ denote the region which is
ithin $C$ but exterior to $\gamma, \gamma', \gamma'', \ldots$ we have by the
theorem on the conversion of integrals taken over
o integrals taken round the boundary of the area,

$$\frac{1}{2\pi}\iint\left[\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\log\{h-f(x,y)\}\right]dxdy$$

satisfied at every point of a periodic orbit; that is, we have the equation

$$\frac{2\{h-f(x,y)\}\{(dx)^2+(dy)^2\}^{\frac{1}{2}}}{\rho}=\frac{\partial f}{\partial x}dy-\frac{\partial f}{\partial y}dx$$

or

$$-2d\gamma=dy\frac{\partial}{\partial x}\log\{h-f(x,y)\}-dx\frac{\partial}{\partial y}\log\{h-f(x,y)\}$$

satisfied at every point of the curve $C$. We have therefore

$$\frac{1}{2\pi}\int_C\left[\frac{\partial}{\partial x}\log\{h-f(x,y)\}dy-\frac{\partial}{\partial y}\log\{h-f(x,y)\}dx\right]$$

$$=-\frac{1}{\pi}\int_C d\gamma=-\frac{2\pi}{\pi}$$

$$=-2.$$

We have next to consider the integrals which arise from the curves $\gamma$, $\gamma'$, $\gamma''$ . . . We shall take first the integral arising from the curve $\gamma$, and, for simplicity, will suppose that the corresponding centre of force is at the origin, so that $\gamma$ is a small circle with the origin as centre, and we can write

$$h-f(x,y)=\frac{\mu}{(x^2+y^2)^{\frac{1}{2}}}+\phi(x,y)$$

where $\mu$ is a constant and $\phi(x,y)$ is a function which is finite and continuous in the vicinity of the origin.

Then for points on $\gamma$ we have, denoting the radius of $\gamma$ by $\rho$,

$$\frac{\partial}{\partial x}\log\{h-f(x,y)\}=\frac{-\frac{\mu x}{\rho^3}+\phi_x(x,y)}{\frac{\mu}{\rho}+\phi(x,y)}$$

$$=-\frac{x}{\rho^2}+\text{terms which, when } \rho \text{ is small, are less important than this.}$$

Similarly

$$\frac{\partial}{\partial y}\log\{h-f(x,y)\}=-\frac{y}{\rho^2}+\text{less important terms.}$$

$$\left[\frac{\partial}{\partial x}\log\{h-f(x,y)\}\,.\,dy-\frac{\partial}{\partial y}\log\{h-f(x,y)\}\,dx\right]$$

$$\int_\gamma (xdy-ydx)+\text{terms which may be neglected in comparison with these}$$

y each of the integrals arising from $\gamma'$, $\gamma''$, . . . has

have

$$\frac{1}{2\pi}\iint_S\left[\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\log\{h-f(x,y)\}\right]dxdy$$

$+1+1+1+\ldots$

of 1's on the right-hand side of the equation being number of centres of force enclosed by the periodic thus

$$\frac{1}{2\pi}\iint\left[\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\log\{h-f(x,y)\}\right]dxdy$$

It may be observed that if the centres of force are not Newtonian, *i.e.* do not attract according to the law of the inverse square of the distance, the method which has been followed will lead to an analogous but slightly different result from that enunciated above.

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## *Comparison of Photographic and Visual Magnitudes of the New Star in Perseus.* By W. H. Robinson.

(*Communicated by Arthur A. Rambaut, M.A., Sc.D., F.R.S., Radcliffe Observer.*)

Observations of the brightness, spectrum, colour, position, motion, and nebulous envelope of *Nova Persei* have from time to time been published, but very few photographic magnitudes of the star have as yet appeared. The results given in the present paper may therefore be of some interest and value.

Visual observations of the new star were commenced at the Radcliffe Observatory on February 25, when the writer—on his own initiative—commenced a series of thirty-three photographs of the region of the *Nova*.

The instrument employed was a half-plate camera with 1-inch doublet of superior quality covering a field of about 30° diameter. The camera was mounted on a small equatorial stand, and was readily adjustable to any desired position. The images of the stars were recorded as trails, no clock-work being introduced. Ilford Special Rapid plates were employed, and the development was effected with pyro-gallic.

The photographic magnitudes given in the present paper have been obtained in the following manner :—

A list of comparison stars, fourteen in number, was first prepared (Table I.), care being taken to select, where possible, only such stars as were in the immediate vicinity of the *Nova*, and evenly distributed around it ; but in order to include the five brightest stars in this list it was found necessary to take in an area greater than that for the nine fainter ones, which are all contained within a field 3° by 5°.

The group of moderately bright stars near *a Persei* is clearly shown on most of the plates, but its zenith-distance is much less than that of the new star, and is in consequence unsuitable for determining magnitudes by the differential method. The inclusion of the stars comprising this group would have necessitated the application of absorption-corrections, more or less doubtful in amount ; and since the density of the trails of stars of any given magnitude increases with their declinations, further slight corrections depending on this cause would have been necessary. For these reasons this group has not been used and has not been included in the list.

The stars selected for comparison of magnitudes with the *Nova* were the following :—

TABLE I.

*List of Comparison Stars.*

| Star's Name. | Tabular Mag. (Harvard Scale.) | Star's Name. | Tabular Mag. (Harvard Scale.) |
|---|---|---|---|
| Capella ... | ... 0·18 | *l* Persei | 4·84 |
| *α* Persei ... | ... 1·94 | 30 Persei | 5·37 |
| *β* Persei ... | ... 2·31 | 36 Persei | 5·40 |
| *ε* Persei ... | ... 3·04 | Arg. Z. + 45°, 811 | 5·64 |
| *δ* Persei ... | ... 3·18 | Arg. Z. + 43°, 818 | 5·97 |
| *ν* Persei ... | ... 3·90 | Arg. Z. + 44°, 734 | 6·23 |
| *κ* Persei ... | ... 4·01 | Arg. Z. + 42°, 795 | 6·30 |

The trails of the comparison stars and *Nova* were examined in transmitted light with a focussing glass, and their densities estimated by steps of sequences on an arbitrary scale of approximately ten or fifteen steps to a magnitude, the brightest star on the plate, *Capella*, being taken as very nearly zero, and *ν Persei* as 50.

The portions of the trails selected for comparison were, with very few exceptions, those corresponding to the same G.M.T.'s of exposures. The reliability of these estimations is strengthened by the fact that not until the final stage of conversion from densities into magnitude had been completed was any reference made to magnitudes of the *Nova* from other sources.

When a series of estimations had been obtained in this way the results were laid aside, and a second examination of the plates, on the same lines, was independently carried out. A duplicate series was thus secured, the results of which exhibited such close agreement with those of the first that further measurements were considered unnecessary.

The two series of results are shown in the following table, each result being the mean of several estimations.

TABLE II.

*Mean Photographic Scale Estimations of Brightness of Comparison Stars.*

| Star's Name. | 1st Series. | 2nd Series. | Adopted Mean. |
|---|---|---|---|
| Capella ... ... ... ... | 4 | 3 | 3·5 |
| *β* Persei ... ... ... ... | 21 | 21 | 21 |
| *α* Persei ... ... ... ... | 23 | 21 | 22 |
| *ε* Persei ... ... ... ... | 29 | 28 | 28·5 |
| *δ* Persei ... ... ... ... | 32 | 32 | 32 |
| *ν* Persei ... ... ... ... | 50 | 50 | 50 |
| *κ* Persei ... ... ... ... | 60 | 59 | 59·5 |
| *l* Persei ... ... ... ... | 63 | 63 | 63 |

| Star's Name. | 1st Series. | 2nd Series. | Adopted Mean. |
|---|---|---|---|
| 30 Persei ... ... ... ... | 66 | 66 | 66 |
| Arg. Z. +45°, 811 ... ... | 68 | 67·5 | 68 |
| 36 Persei ... ... ... ... | 71 | 71 | 71 |
| Arg. Z. +43°, 818 ... ... | 80 | 81 | 80·5 |
| Arg. Z. +44°, 734 ... ... | 81 | 81·5 | 81 |
| Arg. Z. +42°, 795 ... ... | 82 | 82·5 | 82 |

The magnitude-equivalents for the arbitrary scale were next determined.

On square-ruled paper the scaled and tabular values were plotted, the former, from Table II., as ordinates, and the latter, from Table I., as abscissæ; the points thus obtained and a smooth curve drawn through them are exhibited in fig. 1.

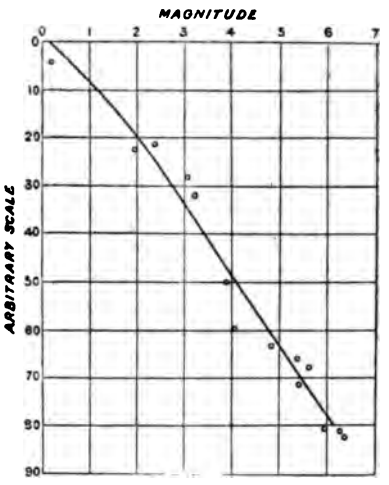



FIG. 1.—The position near 60 scale reading is that of κ Persei, an orange-coloured star.

From this curve the following equivalents were deduced :—

TABLE III.

*Conversion of Scale into Magnitude.*

| Scale. | Magnitude Equivalent. | Scale. | Magnitude Equivalent. |
|---|---|---|---|
| 0 | 0·15 | 30 | 2·75 |
| 5 | 0·65 | 35 | 3·10 |
| 10 | 1·15 | 40 | 3·45 |
| 15 | 1·60 | 45 | 3·75 |
| 20 | 2·00 | 50 | 4·05 |
| 25 | 2·40 | 55 | 4·40 |

| Scale. | Magnitude Equivalent. | Scale. | Magnitude Equivalent. |
|---|---|---|---|
| 60 | 4·75 | 75 | 5·80 |
| 65 | 5·10 | 80 | 6·15 |
| 70 | 5·45 | | |

uivalents given in Table III. were then adopted in
ie photographic magnitudes of the *Nova* shown in
and 6 of Table IV. A satisfactory agreement of the
f magnitudes is shown to exist. The greatest differ-
r at the beginning of the series when the number of
able for comparison was very limited and scattered
nparatively large field, as before stated.

cond column of Table IV. contains the G.M.T. of
The last column gives the visual magnitudes from
bservations, made at nearly the same G.M.T.'s,
in the *Monthly Notices* of the R.A.S., 1901 March,
May.

neral agreement of the last two columns—photographic
magnitudes of the *Nova*—is very striking. On two
April 15 and 20, the differences of magnitude exceed
in both these cases the photographic magnitude is
an the visual.

ght bracketed results in column 7, independently de-
different photographs, are also remarkably accordant.

TABLE IV.

*ison of Photographic and Visual Magnitudes of Nova Persei.*

| Photographic Scale. | | | | | | | Visual |
|---|---|---|---|---|---|---|---|

| No. | G.M.T. | Photographic Scaled Densities. 1st Series. | 2nd Series. | Photographic Magnitudes. 1st Series. | 2nd Series. | Means. | Visual Magnitudes (Means). |
|---|---|---|---|---|---|---|---|
| | 1901. | | | | | | |
| 18 | March 22 $8^h$ | 63·5 | 65 | 5·00 | 5·10 | 5·05 | 5·20 |
| 19 | 23 9 | 45 | 42·5 | 3·75 | 3·60 | 3·68 | 3·92 |
| 20 | 25 8 | 65 | 65·5 | 5·10 | 5·13 | 5·12 | 5·15 |
| 21 | 11 | 65 | 66 | 5·10 | 5·17 | 5·13 | |
| 22 | 26 9 | 49 | 48·5 | 3·99 | 3·96 | 3·98 | 4·12 |
| 23 | 27 8 | 45 | 47 | 3·75 | 3·87 | 3·81 | 3·98 |
| 24 | 11 | 47 | 46 | 3·87 | 3·81 | 3·84 | |
| 25 | 28 9 | 61·5 | 59 | 4·85 | 4·68 | 4·76 | 4·61 |
| 26 | 30 $9\frac{1}{2}$ | 49·5 | 48 | 4·02 | 3·93 | 3·98 | 4·14 |
| 27 | $10\frac{1}{2}$ | 50 | 49 | 4·05 | 3·99 | 4·02 | |
| 28 | April 10 9 | 68 | 69 | 5·31 | 5·38 | 5·34 | 5·33 |
| 29 | 13 9 | 55·5 | 53 | 4·43 | 4·26 | 4·35 | 4·49 |
| 30 | 15 11 | 68 | 68 | 5·31 | 5·31 | 5·31 | 5·82 |
| 31 | 17 9 | 59 | 58 | 4·68 | 4·61 | 4·64 | 4·62 |
| 32 | 19 $9\frac{1}{2}$ | 67 | 70 | 5·24 | 5·45 | 5·34 | 5·13 |
| 33 | 20 9 | 71 | 71·5 | 5·52 | 5·56 | 5·54 | 5·83 |

No. 2. Not in good focus. Nos. 9 and 10. Very faint; very misty sky. No. 11. Images not good, too near edge of plate. No. 19. Varying images; cloudy. No. 30. Small altitude; trails good. No. 32. Very faint.

The last two columns of Table IV. are represented graphically in fig. 2. The ordinates of the two curves are, for the sake of clearness, separated by a constant quantity (one magnitude); unless this had been done the curves would have been superposed in places and would have presented a confused appearance.

A glance at this diagram will show that every change of

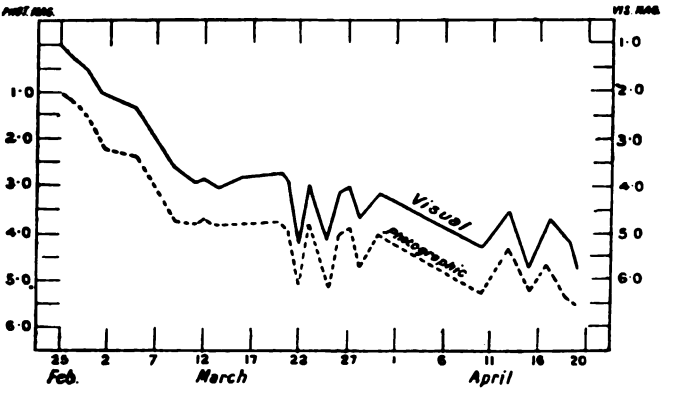



FIG. 2.—Comparison of Photographic with visual magnitude of Nova Persei.

as determined visually has its counterpart in the
c curve, so that the two corroborate each other in
ular.

llelism or identity of the curves in this figure appear
markable when it is remembered that the *spectrum* of
exhibited considerable fluctuations in unison with
gnitude, as proved by the extensive series of spectro-
vations at Kensington and Stonyhurst. The director
r observatory, in a paper recently communicated to
*mische Nachrichten* (No. 3756), says:—

parison of all the photographic plates of the star's
tained at Stonyhurst with the light-changes observed
liffe Observatory, Oxford, has shown that the changes
rum follow, not the phases of the light-curve, but the
gnitudes of the star's brightness. The new spectrum,
st appeared to be associated with the minimum phase,
n all the dates on which the star's magnitude was less
oth in March and April; and the old spectrum always
hen the magnitude was greater than 4·57."

man Lockyer (*Proc. R.S.*, vol. lxviii. 231) writes:—
panying the great diminution in the light of the *Nova*
the evening of the 25th [March], the spectrum was
ave undergone a great change: the continuous spec-
practically disappeared, and a line near D (probably
became more distinct. The other lines were hardly
The same astronomer further remarks:—"It has been
the lines 447, 501, and D, appear to vary with the

brought out clearly by Mr. H. Ellis in his paper entitled "Notes on some Photographs of *Nova Persei*," published in the *Journal of the British Astronomical Association*, vol. xi. No. 6. Mr. Ellis took his pictures of the *Nova* with a 5-inch portrait lens and with a large mirror on several nights from February 25 to March 10, using Ilford Special Rapid plates (carefully backed). He remarks:—"In examining these plates, it is very noticeable that the image of the *Nova* is large; in fact, it does not seem to have diminished in size, although by March 10 its light had much diminished and become very orange, with flashes of crimson, when viewed in the guiding telescope."

It will be seen in Table IV. of the present paper that a fall of nearly three magnitudes occurred between February 25 and about March 10.

Mr. Ellis proceeds: "In all the plates the image is larger than *a Persei*. . . . The reason of this, I think, must be the large gaseous envelope which the spectroscope shows to be present."

The nebulous envelope, if it existed at the time of Mr. Ellis' photographs, was not sufficiently actinic to be photographed with short exposures or by the trail method. The exposures by the trail method (within small limits of declination) possess the exceptional merit of being not only *short* but *always equal*; and these conditions seem to be essential when photographs of an object such as the *Nova* are required for comparison from night to night.

The chemically active quality of the light of the new star is emphasised by contrast with that of other reddish stars. This is shown on plate No. 7 (March 9, $9^h$), which, after being exposed on the Nova, was exposed on the first magnitude orange-red star *a Orionis*, when it was at the same altitude as the new star and probably not so red.* From a discussion of the data afforded by this plate the resulting magnitudes were found to be:

| | Photographic. | Visual. |
|---|---|---|
| *a Orionis* ... ... ... | 3·20 | 0·91† |
| *Nova Persei* ... ... | 3·77 | 3·61 |

It may be mentioned, in conclusion, that the trails were examined for any evidence of rapid changes of light similar to those seen on February 24 by Herr Archenhold,‡ but no sudden changes were found, except such as were attributable to atmospheric causes.

*Radcliffe Observatory, Oxford:* 1902 *January* 6.

* *Nova röthlich.* Harkányi (*A.N.* 3706). *Nova tief roth.* Köhl (*A.N.* 3709).

† Harvard Photometry.

‡ "Die plötzliche Lichtabnahme der Nova und ihr völliges Verschwinden waren so etwas Aussergewöhnliches, dass ich zunächst an eine atmosphärische Ursache dachte. Nur der Umstand, dass ich die umliegenden schwachen Sterne wie $\nu$, $\psi$, $\delta$, und $\sigma$ Persei während dieser Zeit deutlich wahrnahm, liessen auch die Möglichkeit zu, dass es eine wirkliche Lichtabnahme der Nova sei" (*Ast. Nach.* No. 3694).

## *Period and Light Curve of* 6685 *Y Lyræ.**

By A. Stanley Williams.

rlier observations of this star seemed to su
long period, and one of about eighty-six da
by Dr. Hartwig in 1900,† whilst at about th
ought it might be forty-two days, or about h
e. Observations of the star were commenced
with the object of solving this question, an
proceeded for some time it became evident t
was actually a very short one. The questi
cided on August 18, on which date the st
hortly before the rise from minimum had com
ed up to and past maximum; whilst further o
showed that the true period was very nearly
ut the same time Dr. Hartwig was making a s
ns of the star at the Bamberg Observatory
servations are referred to in *A.N.* 3744.‡ The
e, but further observations in the latter
de him suspect that the variable had a short
ig was unable to continue his observations at th
h he was able to fully confirm the rapid variabilit
is observations are in good agreement with the
sults contained in the present paper are based
9 visual observations. Fourteen of these wer

with the variable we may always observe with the eyes parallel to, or in some fixed position with respect to, a line joining the two stars observed. The first of these methods will undoubtedly give the best results, since with it the effects of position error must be altogether eliminated. Its only drawback is that the time and labour required are both much increased—a serious matter, especially in the case of a faint and rapidly varying star.* Method (2) was made use of in the present series of observations.† The group was always observed so that a line through the stars A and *b* (see diagram below) was normal to a line through the eyes, *b* being above. By this method the effects due to position error are not eliminated, so far as regards the absolute magnitude of the star observed, but the observations will be strictly comparable *inter se*.‡




* In connection with this method and the question of position error generally reference should be made to the valuable papers by Dr. A. W. Roberts in the *Monthly Notices*, vol. lvii. p. 483, and vol. lix. p. 524.

† These remarks relate only to the Hove observations except where otherwise mentioned. Method (3) seems preferable on the whole to method (2), and is the one at present made use of by the writer. The reflector with rotating tube is very convenient for either method.

‡ The effect of a complete reversal of position is to produce a change of about half a magnitude in the relative brightness of two stars observed in a direction normal to a line through the eyes by the writer.

mparison stars used are shown in the pre
The observations were made by the meth
, and the step values of the different comp
rived from the very numerous comparisons b
nd the variable, are as under :—

| ıp. Star. | Step Valu·. | Adopted Mag. |
|---|---|---|
| *c* | 0·0 | 10·70 |
| *h* | 5·5 | 11·09 |
| *k* | 13·0 | 11·63 |
| *m* | 14·8 | 11·75 |
| *n* | 18·1 | 11·99 |
| *l* | 19·7 | 12·10 |

gnitude of the star *c* was assumed to be 10·7,
sibility in a $2\frac{3}{4}$-inch refractor. On a clear nig
ctly and *steadily* visible, with a power of 75
. The $6\frac{1}{2}$-inch reflector has been considered t
nd steadily stars down to $12^{m}\cdot5$ on clear night
110. The comparison star *l* is near, though de
limit, and its magnitude has been assumed to b
the foregoing values for *c* and *l*, the magnitudes
parison stars, as determined from the step valu
e last column of the above table, the value of
71. With reference to the comparison stars,
ed that *c*, *h*, and *l* have always appeared ste
and the comparisons made with them were

The comparisons with *l* were given increased weight because this star proved more satisfactory than any of the others. All the observations were reduced with the above weights, excepting that in a few cases less weights were assigned when the notes made at the time of observation seemed to show that this was necessary.

From a preliminary determination from 5 maxima observed between 1901 August 19 and October 20 the period of variation was found to be approximately $12^h\ 3^m\ 40^s{\cdot}6$. For the final determination of this element, however, photographic observations have been used, chiefly on account of the much greater length of time available. Two photographs, dated 1899 December 31 and 1900 September 3, show the variable exactly of the same relative brightness with respect to *c*, in both the two stars appearing as a double star with slightly unequal components.* These photographs were taken with a 4·4-inch portrait lens of about 20 inches equivalent focus, and a third one obtained with the same instrument on 1901 November 5 also shows the variable of the same brightness with respect to *c*. In the case of photographs of a rapidly varying star there is necessarily some uncertainty as regards the exact time corresponding to the image of the star on the plate. As the exposures are not very dissimilar,† it has been assumed in the present instance that this time corresponds to the middle of the exposures. As we are now only concerned with the period of variation, and not with the time of maximum, it is immaterial whether this assumption is correct or not, provided that this time corresponds to the same phase in all the photographs. Below are given the date and heliocentric Greenwich mean time of the exposures and the duration of the latter. The fifth column contains the interval in time by which the observations follow the adopted epoch of $T_o$‡, and the last column the difference from the mean.

| Plate. | Date. | Time. | Exposure. | Interval from $T_o$. | Diff. from Mean. |
|---|---|---|---|---|---|
| | | h m | m | h m | m |
| 46 | 1899 Dec. 31 | 6 40·4 | 63 | 0 54·2 | −0·6 |
| 63 | 1900 Sept. 3 | 14 19·3 | 45 | 0 56·7 | +1·9 |
| 149 | 1901 Nov. 5 | 9 9·4 | 32 | 0 53·6 | −1·2 |

From these three observations the period of variation is :—

$$0^d{\cdot}5026876 = 12^h\ 3^m\ 52^s{\cdot}21$$

The remarkably close accordance of the three observations is no

* The photographic brightness of the variable is the same as the visual.

† Plate 46 was exposed longer than the others, but the night was slightly hazy, particularly towards the end, and this would tend to equalise matters.

‡ The time $T_o$, as explained further on, is the time when the variable attains to equality with the comparison star *l* in its rapid rise from minimum to maximum.

extent an accident, but the star varies so rapidly
of maximum that I cannot think that any one of
error by as much as $10^m$, and the above period
rong owing to the considerable interval of time
e observations, 1,341 periods being included
irst and last. It also satisfies all the visual

se from minimum to maximum occurs with great
stant when the variable attains to equality with
star *l* has been adopted as the principal epoch.
lesignated by $T_o$. There are twelve nights on which
as observed from minimum to maximum, and on
the maxima were also completely observed. The
each of these twelve nights were plotted separately
paper, and a light curve drawn. From these
e times of $T_o$, and also the times of maximum,
ed by measurement. No mean light curve was
this part of the work, but the results for each
rived separately from the observations of that
eason for this was, chiefly, that some of the
o have been less acute than others, and I am not
his is all due to errors of observation. But though
ffer slightly in this way, the rise from minimum
um is in every case represented by a straight line,
e $T_o$ can be very exactly determined. Table I.,
s the dates and heliocentric Greenwich mean
The mean of these times, corresponding to 1901
$12^h\ 20^m$ has been adopted as the principal

of observing and to the favourable weather prevailing at that time. No. 11 is from observations by Dr. Hartwig, and the residual here includes any error in the reduction of his observations to the scale of the others. With regard to this point there is a little uncertainty, since the Bamberg observations, made with a refractor, seem to make the star a little brighter than those made with the reflector.*

Table II., below, contains the observed times of maximum, with the intervals by which these follow the observed times of $T_o$.

TABLE II.

*Observed Maxima.*†

| Date. | Greenwich M.T. h m | Interval from $T_o$. h m |
|---|---|---|
| 1901 Aug. 18 | 11 51 | 1 29 |
| 19 | 11 32 | 1 22 |
| 20 | 11 34 | 1 24 |
| 21 | 11 33 | 1 3 |
| 22 | 11 33 | 0 53 |
| 23 | 11 45 | 1 4 |
| 24 | 12 13 | 1 23 |
| 26 | 12 11 | 1 0 |
| Sept. 4 | 13 32 | 1 25 |
| Oct. 20 | 7 10 | 0 59 |
| Nov. 3 | 9 12 | 1 0 |

The mean of the times in the last column is $71^m$, but from the mean light curve the interval is $60^m$. The latter has been adopted as the true interval. The separate results vary from $53^m$ to $89^m$, a difference which seems too great to be ascribed wholly to errors of observation.

The reduced observations of magnitude, having been arranged in order of distance from the time $T_o$, were formed into groups.

* Dr. Hartwig's observations are given below. The last column contains the magnitude according to the adopted scale.

| | Greenwich M.T. h m | m | | Mag. |
|---|---|---|---|---|
| 1901 Oct. 25 | 7 1 | *c* 0·74 Y | | 12·08 |
| | 7 12 | *c* 0·7 Y | | 12·03 |
| | 7 23 | *c* 0·4 Y | $0^m{\cdot}35$ *l* | 11·46 |
| | 7 33 | *c* 0·25 Y | $0^m{\cdot}5$ *l* | 11·17 |
| | 7 41 | *c* 0·15 Y | | 10·98 |
| | 7 57 | *c* 0·15 Y | $0^m{\cdot}6$ *l* | 10·98 |

The night was not favourable, and cloud stopped observation after $7^h\ 57^m$. The rapid rise from near minimum to maximum is, however, very well shown, and, as in my observations, is represented by a straight line.

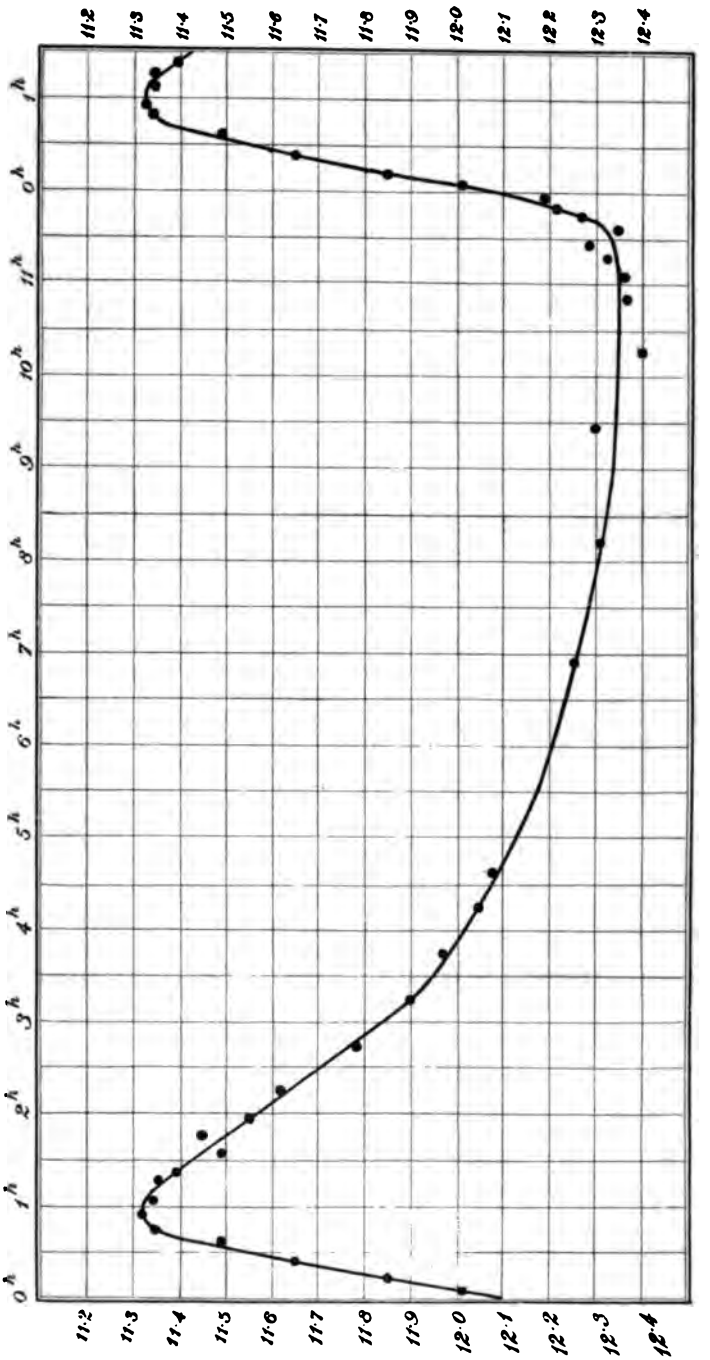
† Not reduced to the Sun.

before and two hours after $T_o$ the observations lected into 10-minute groups. The interval of $14^m$ s epoch was divided into two equal groups. For portion of the period the observations have been alf-hourly groups, excepting between $5^h$ and $10^h$ re they are not numerous enough to permit of this. ntains the results of this grouping.

TABLE III.

*Grouped Observations.*

| al | Observed Magnitude. | Magnitude from Curve. | O−C. | Weight. | No. of Obs. |
|---|---|---|---|---|---|
| | 12·01 | 12·01 | m 0·00 | 37 | 12 |
| | 11·85 | 11·85 | ·00 | 48 | 10 |
| | 11·65 | 11·65 | ·00 | 54 | 13 |
| | 11·49 | 11·48 | + ·01 | 37 | 11 |
| | 11·35 | 11·35 | ·00 | 43 | 11 |
| | 11·33 | 11·33 | ·00 | 38 | 9 |
| | 11·35 | 11·33 | + ·02 | 38 | 9 |
| | 11·35 | 11·36 | − ·01 | 14 | 4 |
| | 11·39 | 11·39 | ·00 | 32 | 8 |
| | 11·49 | 11·44 | + ·05 | 19 | 4 |
| | 11·44 | 11·48 | − ·04 | 33 | 9 |
| | 11·54 | 11·54 | ·00 | 17 | 5 |




*Light Curve of Y Lyræ.*



In the above table col. 1 contains the number of the group; col. 2, the interval from $T_0$; col. 3, the observed magnitude, this being the weighted mean of the observations forming the group; col. 4, the mean magnitude, measured from the mean light curve; col. 5, the residual, observed − curve; col. 6, the weight, this being merely the sum of the weights of the separate observations; and col. 7, the number of observations to the group.* The 30 observed magnitudes having been plotted upon a large scale diagram, the mean light curve was carefully drawn, and the magnitudes in the 4th col. were measured from this. This light curve, on a smaller scale, is reproduced in Plate 7. The observations are in very satisfactory accordance, the average deviation of a group from the mean light curve being only 0·014 mag., whilst no residual exceeds 0·05 mag. It should be mentioned, moreover, that the observations forming a group are also generally very accordant, and that no observation has been rejected for discordance. The only observations not used consist of a few in which the variable was not seen, and was accordingly noted only as being fainter than a certain magnitude.

It will be seen that the mean light curve presents some rather peculiar features. The rise from minimum to maximum is very rapid; whilst immediately after the latter is attained the decline sets in, and the fall, though not so rapid as the rise, is yet very quick for the first two hours after maximum. One result of this is that the variable is only at all bright for about three hours out of the twelve, and for the remaining nine hours it is more or less faint. The light curve has thus a very close resemblance to that of what has been termed the "cluster type" of variable. This type has been recently described very fully in an interesting article by Professor S. I. Bailey,† in which the approximate light curves from photographic observations of eight of the variables in the cluster Messier 5 are reproduced. Reference should also be made here to a paper by Professor E. E. Barnard ‡ on visual observations of some of the variables in the same cluster, and to one by Professor E. C. Pickering § on the rate of increase of the light of three variable stars in the cluster Messier 3. In length of period also the present variable star bears a close resemblance to those of the cluster type, the average period of forty variables in Messier 5 being $12^h\ 37^m{\cdot}4$ according to Bailey, whilst the periods of the three in Messier 3 investigated by Pickering are stated to be $12^h\ 12^m\ 25^s$, $12^h\ 0^m\ 15^s$, and $12^h\ 24^m\ 31^s$.

Although the presence of so many variables of the type in star clusters would seem to show that such a condition is

* Each of these separate observations is itself generally based on comparisons with from two to four comparison stars.

† *Astrophysical Journal*, vol. x. pp. 255–260.

‡ *A.N.* 3519.

§ *Astrophysical Journal*, vol. xii. p. 159. See also a valuable paper by the same writer on variable stars in clusters in *A.N.* 3525.

le to give rise to this kind of variation, yet the solated stars, like *Y Lyræ*, belonging to the same ndicate that it is not an essential condition. In ne type is not peculiar to clusters.

*Elements of Y Lyræ.*

| | | |
|---|---|---|
| ariation ... | ... | $0^d \cdot 5026876 = 12^h\ 3^m\ 52^s \cdot 21$. |
| ... ... | ... | 1901 Sept. 4, $12^h\ 20^m$ G.M.T. (J.D. 2415632·5138.) |
| aximum ... | ... | 1901 Sept. 4, $13^h\ 20^m$ G.M.T. (J.D. 2415632·5554.) |
| rightness | ... | $11^m \cdot 32$. |
| ,, | ... | $12^m \cdot 35$.* |
| maximum | ... | $1^h\ 40^m$.† |
| minimum | ... | $10^h\ 24^m$. |
| se to decrease | ... | 0·16. |

*Computed Times of* $T_0$.‡

| G.M.T. h m | 1902. | G.M.T. h m |
|---|---|---|
| 3 6 | Aug. 9 | 19 52 |
| 4 23 | 19 | 21 10 |
| 5 41 | 29 | 22 27 |
| 6 58 | Sept. 8 | 23 44 |
| 8 16 | 18 | 0 54 |

Σ 1639. 68 *Comæ Berenicis.* By Thomas Lewis.

R.A. $12^h\ 19^m\ 25^s$ } 1900 Mag. A 6·7
N.P.D. $63°\ 52'$ } Mag. B 7·9

The measures commence in 1827 by W. Struve; but they are few in number owing to the closeness of the components since 1880. It is undoubtedly binary, and as the distance is now increasing again it will become a fairly easy object and is worth attention.

Of course the orbit here given is only approximate, and is intended merely to call attention to the pair.

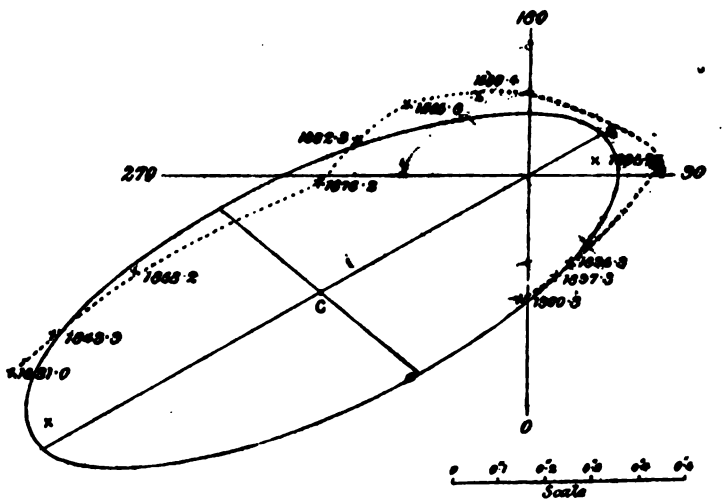
The annual means of the measures are :—

| Year. | Angle. | Distance. | |
|---|---|---|---|
| 1827·28 | 291°·2 | 1″·27 | Σ (1) |
| 29·39 | 289·7 | 1·15 | Σ (3) |
| 36·49 | 292·8 | 1·18 | Σ |
| 41·39 | 289·7 | 1·03 | OΣ (1) |
| 42·37 | 285·5 | 1·19 | OΣ (2) |
| 43·33 | 293·7 | 0·98 | Maed. (1) |
| 44·32 | 289·2 | 1·18 | OΣ (1) Maed. (1) |
| 48·35 | 288·8 | 0·96 | Maed. (1) |
| 55·32 | 282·2 | 0·97 | OΣ (1) |
| 56·48 | 288·1 | 0·87 | Secchi (1) |
| 57·33 | 283·6 | 0·84 | Secchi (1) |
| 58·34 | 283·0 | 1·00 | De (4) |
| 63·16 | 285·7 | 0·67 | De (4) |
| 70·31 | 275·8 | 0·74 | OΣ (1) |
| 75·25 | 273·6 | 0·40 | De (1) Schiap. (4) |
| 76·46 | 272·6 | 0·39 | De (1) |
| 77·41 | 271·4 | 0·40 | De (1) Schiap. (4) |
| 78·31 | 268·3 | 0·36 | De (1) |
| 79·31 | 268·7 | 0·4 | Schiap. (2) |
| 81·37 | 260·7 | 0·4 | Schiap. (2) |
| 82·39 | 258·1 | 0·39 | Schiap. (4) |
| 83·30 | 259·5 | 0·34 | Engel (16) Schiap. (3) |
| 84·37 | 243·7 | 0·38 | Schiap. (2) |
| 85·41 | 249·0 (?) | ... | Schiap. (2) |
| 87·39 | 236·0 | 0·22 | Schiap. |
| 89·40 | 215·6 | 0·2 | H. Struve (1) |
| 90·46 | Single | | H. Struve |

| Angle. | Distance. | |
|---|---|---|
| ° Single | " | Burnham (36-inch) |
| Single | | Lewis (13-inch) |
| Single | | Lewis (28-inch) |
| 97·1 | 0·28 | Lewis (1) |
| 25·4 | 0·2 | H. Struve (3) |
| 19·3 | 0·15 | Lewis (1) |
| 12·7 | 0·25 | Aitken (3) Lewis (2) |
| 9·7 | 0·27 | Aitken (3) Lewis (1) |
| 3·0 | 0·26 | Aitken (3) Lewis (3) |
| 356·9 | 0·19 | Bowyer (3) Lewis (3) |
| 356·7 | 0·32 | Aitken (3) Lewis (3) Bryant (1) |

hese measures we adopt the following six positions
eans of neighbouring years—

| | ° | " |
|---|---|---|
| 1831·05 | 291·2 | 1·20 |
| 43·94 | 289·4 | 1·07 |
| 58·21 | 284·5 | 0·87 |
| 76·21 | 271·6 | 0·45 |
| 82·35 | 259·4 | 0·38 |
| 85·88 | 239·9 | 0·30 |




These positions are shown in the figure which is the adopted apparent ellipse, from which the following elements for the true ellipse have been computed :—

| | | | |
|---|---|---|---|
| $\tau$ | = 1892·0 | $\Omega$ | = 109° 12′ |
| $p$ | = 180 years | $\lambda$ | 18 7 |
| $\epsilon$ | = 0·70 | $\gamma$ | 58 9 |
| $a$ | = 0″·71 | $\phi$ | 42°·88 |

The measures of H. Struve were received after this paper was written. They uphold the binarity and conclusions here given in the most decided manner.

1901 *December* 28.

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## *Observations of the Satellite of Neptune from Photographs taken at the Royal Observatory, Greenwich, in* 1899–1900.

(*Communicated by the Astronomer Royal.*)

By inadvertence the publication of these results for the opposition of 1899–1900 has been delayed till now.

The photographs were taken with the 26-inch refractor of the Thompson equatorial. An occulting shutter immediately in front of the plate has been used to screen the planet during the greater part of the long exposure on the satellite, a series of very short exposures (usually twenty of one second each) being given to

regular intervals (usually each minute) by lifting the rm. The orientation was determined usually by pair of short-exposure images of *Neptune*, the clock ut of gear for seven seconds between the exposures to enient displacement in R.A. The photographs were n reversed positions of the plate by each of two The mean values of position angle and distance as e given in the following table, the tabular positions uted from the data given in the *Connaissance des* d on Mr. H. Struve's elements, the eccentricity of eing neglected owing to the uncertainty as to the tion of the periastron.

*of Neptune's Satellite measured on Photographs taken with the 26-inch Refractor.*

| Exposures. | Position angle. | | | Distance. | | |
|---|---|---|---|---|---|---|
| | Observed. | Tabular. | Tab.−Obs. | Observed. | Tabular. | Tab.−Obs. |
| m s. | ° | ° | ° | ″ | ″ | ″ |
| 30 & 15 | 53·09 | 51·95 | −1·14 | 14·37 | 14·41 | +0·04 |
| 30 & 20 | 42·67 | 39·57 | −3·10 | 12·81 | 13·12 | +0·31 |
| 30 & 10 | 261·23 | 261·88 | +0·65 | 16·74 | 16·56 | −0·18 |
| 30 & 10 | 32·27 | 32·55 | +0·28 | 12·90 | 12·46 | −0·44 |
| 20 & 10 | (80·52) | 83·08 | (+2·56) | ... | ... | ... |
| 20 & 20 | 42·34 | 41·73 | −0·61 | 14·45 | 13·81 | −0·64 |
| 30 & 20 | 28·55 | 29·33 | +0·78 | 12·35 | 12·49 | +0·14 |

## *Observations of Occultations of Stars by the Moon and Phenomena of Jupiter's Satellites, made at the Royal Observatory, Greenwich, in the Year* 1901.

(*Communicated by the Astronomer-Royal.*)

| Day. 1901. | | Phenomenon. | Telescope. | Power. | Moon's Limb. | Mean Solar Time of Observation. h m s | Observer. |
|---|---|---|---|---|---|---|---|
| March | 26 | Disapp. 68 Orionis | Astrographic Equat. | 225 | Dark | 9 13 58·04 | W. |
| April | 22 | ,, Lalande 11088 | Great Equat. (Corbett) | 100 | ,, | 9 25 20·88 | H. F. |
| | 22 (*a*) (*b*) | ,, $\chi^2$ Orionis | Astrographic Equat. | 225 | ,, | 10 25 0·03 | R. |
| | 23 (*a*) | ,, W. B. (2) VI. 1200 | Old Altazimuth | 100 | ,, | 8 5 54·76 | A. C. |
| | 23 (*a*) | ,, ,, | Sheepshanks Equat. | 55 | ,, | 8 5 54·85 | W. B. |
| | 23 | ,, ,, | Astrographic Equat. | 225 | ,, | 8 5 54·57 | S. |
| | 23 | Reapp. ,, | Sheepshanks Equat. | 55 | Bright | 8 23 59·51 | W. B. |
| | 28 (*b*) | Disapp. $p^2$ Leonis | Great Equat. | 670 | Dark | 10 42 18·68 | B. |
| May | 31 | ,, Piazzi XV. 96 | Sheepshanks Equat. | 120 | ,, | 11 48 44·94 | A. C. |
| June | 4 | Reapp. Lalande 35497 | ,, ,, | 120 | ,, | 12 41 47·97 | B. |
| | 29 | Disapp. Lalande 30725 | Astrographic Equat. | 225 | ,, | 8 45 47·44 | H. |
| July | 28 (*b*) | ,, 21 Sagittarii | ,, ,, | 225 | ,, | 9 50 35·54 | R. |
| Aug. | 24 (*c*) | ,, Piazzi XVII. 323 | ,, ,, | 225 | ,, | 8 46 48·78 | G. B. |
| Oct. | 22 (*d*) | ,, $c^1$ Capricorni | | | ,, | No Occultation | A. C., R. |
| | 23 (*b*) (*c*) | ,, $\kappa$ Aquarii | Great Equat. | 670 | ,, | 8 52 47·81 | B. |
| | 27 (*e*) | ,, 29 Arietis | Astrographic Equat. | 225 | Bright | 12 14 58·90 | H. |
| | 27 (*f*) | Reapp. ,, | ,, ,, | 225 | App. Bright | 13 7 24·02 | H. |

| | | | | | |
|---|---|---|---|---|---|
| uat. | 670 | Bright | 8 | 7 40·59 | B. |
| ks Equat. | 120 | " | 8 | 7 (55) | W. B. |

(*e*) Star appeared to glide up to and behind limb.
(*f*) Observer noted "possibly 0ˢ·5 late." The limb was apparently bright, the width of the dark lune being about 1″.
but (*g*) The time was noted as "doubtful" by the observer, and is evidently erroneous.

*a of Jupiter's Satellites.*

| Telescope. | Power. | Mean Solar Time of Observation. h m s | Mean Solar Time of *N.A.* h m | Observer. |
|---|---|---|---|---|
| heepshanks Equat. | 100 | 9 35 6·29 | | H. |
| " " | " | 9 40 5·48 | 9 43 | " |
| " " | " | 9 44 14·79 | | " |
| " " | " | 9 44 34·74 | | " |
| " " | " | 9 50 3·84 | 9 44 | " |
| " " | " | 9 58 32·43 | | " |
| strographic Equat. | 225 | 9 51 47·36 | 9 52 | R. |

| Day. 1901. | Satellite. | Phenomenon. | Telescope. | Power. | Mean Solar Time of Observation. h m s | Mean Solar Time of *M.A.* h m | Observer. |
|---|---|---|---|---|---|---|---|
| July 27 | II. | Occ. D. First contact | Astrographic Equat. | 225 | 10 12 45·02 | | H. |
| 27 | II. | Bisection | ,, ,, | ,, | 10 16 14·45 | 10 15 | ,, |
| 27 | II. | Last seen | ,, ,, | ,, | 10 18 54·00 | | ,, |
| Aug. 7 | I. (*b*) | Occ. D. First contact | ,, ,, | ,, | 10 28 51·56 | | ,, |
| 7 | I. | Bisection | ,, ,, | ,, | 10 31 41·10 | 10 35 | ,, |
| 7 | I. | Last seen | ,, ,, | ,, | 10 36 30·31 | | ,, |

(*a*) Limb unsteady, cloudy.

(*b*) Limb rather diffused and tremulous, but the observation considered good.

The apertures of the telescopes used are as follows :—

| | inches. | | inches. |
|---|---|---|---|
| Great Equatorial ... ... ... ... | 28 | Great Equatorial (Corbett Telescope) ... | 6½ |
| Astrographic Equatorial (Guiding Telescope) | 10 | Old Altazimuth ... ... ... ... | 4 |
| Sheepshanks Equatorial ... ... ... | 6¼ | | |

The initials H., A. C., B., W. B., R, H. F., W., S., G. B., W. H. B., are those of Mr. Hollis, Mr. Crommelin, Mr. Bryant, Mr. Bowyer, Mr. Rendell, Mr. Furner, Mr. Witchell, Mr. Showell, Mr. Bischlager, and Mr. Brookes respectively.

*Royal Observatory, Greenwich:* 1902 *January* 8.

*Errata in Mr. Saunders' paper.*

page 189, lines 12, 21 (twice).

,, 46, last line, and page 47, 8th line from bottom,
*for* (Dr. — Eu) *read* (Eu — Dr.)

# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. LXII. FEBRUARY 14, 1902. No. 4

GLAISHER, M.A., F.R.S., PRESIDENT, in the Chair.

Ambrose Kibbler, M.B., Ashby House, 3 Manor Stamford Hill, N.;
F. Sandberg, M.A., Oxon, Lancing College, Shoreham, ;
Valter, Royal Alfred Observatory, Mauritius; and Fawcett White, Navigation Department, Merchant rers' Technical College, Bristol,

l for and duly elected Fellows of the Society.

owing Candidates were proposed for election as he Society, the names of the proposers from personal eing appended :—

Herbert Bryant, Science Master, Hipperdale Schools, ford, Gloucestershire (proposed by Albert Taylor);
P. Lenox-Conyngham, R.E., Survey of India,

## Report of the Council to the Eighty-Second Annual General Meeting of the Society.

The following table shows the progress and present state of the Society :—

| | Compounders | Annual Subscribers | Total Fellows | Associates | Patron | Grand Total |
|---|---|---|---|---|---|---|
| 1900 December 31 ... ... ... | 250 | 375 | 625 | 46 | 1 | 672 |
| Since elected ... ... ... ... | + 6 | +22 | ... | + 3 | ... | ... |
| Deceased ... ... ... ... ... | − 6 | − 7 | ... | − 3 | ... | ... |
| Resigned ... ... ... ... ... | ... | −11 | ... | ... | ... | ... |
| Removals ... ... ... ... ... | ... | ... | ... | ... | ... | ... |
| Expelled ... ... ... ... ... | ... | − 4 | ... | ... | ... | ... |
| 1901 December 31 ... ... ... | 250 | 375 | 625 | 46 | 1 | 672 |

*Mr. Maw's Report as Treasurer of the*

RECEIPTS.

| 1 January 1:— | £ | s. | d. | £ |
|---|---|---|---|---|
| kers', as per Pass-book ... ... | 535 | 4 | 4 | |
| not credited till 1901 ... ... | 4 | 4 | 0 | |
| d of Assistant Secretary on Petty Account ... ... ... ... | 10 | 4 | 6 | |
| | | | | 54 |
| £1,250 Metropolitan 3-per-cent. Stock | 35 | 7 | 11 | |
| £932 19 0 Metropolitan 2½-per-cent. ... ... ... ... ... ... | 22 | 0 | 4 | |
| £3,400 East Indian Railway 3-per-enture Stock ... ... ... ... | 96 | 5 | 3 | |
| £3,200 London and North-Western 3-per-cent. Debenture Stock ... ... | 91 | 0 | 0 | |
| ividend on £3,600 Midland Railway nt. Debenture Stock ... ... ... | 42 | 15 | 0 | |
| ividend on £4,000 Midland Railway nt. Debenture Stock ... ... ... | 47 | 5 | 10 | |
| £1,860 Gas Light and Coke Co. t. Debenture Stock ... ... ... | 52 | 17 | 10 | |
| £1,100 Commercial Gas Co. 4½-per-enture Stock ... ... ... ... | 46 | 14 | 3 | |
| 300 on Deposit at Bankers' ... ... | 3 | 0 | 7 | |
| | | | | 43 |

ccount of Subscriptions:—

*Astronomical Society, from* 1901 *January* 1 *to December* 31.

EXPENDITURE.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Assistant Secretary: Salary ... ... ... | 250 | 0 | 0 | | | |
| " " for assistance in editing Society's Publications ... | 50 | 0 | 0 | | | |
| | | | | 300 | 0 | 0 |
| House Duty ... ... ... ... ... ... | 2 | 12 | 6 | | | |
| Fire Insurance ... ... ... ... ... | 9 | 9 | 6 | | | |
| | | | | 12 | 2 | 0 |
| Printing *Monthly Notices* ... ... ... ... | 459 | 12 | 8 | | | |
| " Appendix to *Monthly Notices* ... ... | 30 | 3 | 0 | | | |
| " " *Memoirs* ... ... ... | 14 | 16 | 0 | | | |
| " Supplementary Library Catalogue ... | 64 | 18 | 9 | | | |
| " List of Fellows, Charter and Bye-Laws, and Miscellaneous ... ... ... | 23 | 19 | 0 | | | |
| | | | | 593 | 3 | 5 |
| Computation of Ephemerides in *Monthly Notices* ... | | | | 15 | 0 | 0 |
| Turnor and Horrox Funds: Purchases for Library | 21 | 9 | 10 | | | |
| Folios and mounts for drawings in Library ... | 6 | 2 | 6 | | | |
| | | | | 27 | 12 | 4 |
| Reproduction of Photographs ... ... ... | | | | 21 | 12 | 8 |
| Cataloguing astronomical literature for the International Catalogue of Scientific Literature ... | | | | 30 | 0 | 0 |
| Clerk's Wages ... ... ... ... ... | 52 | 0 | 0 | | | |
| Postage and Telegrams ... ... ... ... | 84 | 8 | 3 | | | |
| Carriage of Parcels, &c. ... ... ... | 3 | 5 | 2 | | | |
| Stationery (Spottiswoode & Co.) ... ... | 4 | 4 | 6 | | | |
| Sundry Stationery and Office Expenses ... ... | 3 | 7 | 4 | | | |
| | | | | 147 | 5 | 3 |
| Expenses of Meetings ... ... ... ... | 20 | 0 | 0 | | | |
| Lantern Expenses ... ... ... ... ... | 10 | 15 | 0 | | | |
| Time Signal, &c. ... ... ... ... ... | 6 | 10 | 0 | | | |
| | | | | 37 | 5 | 0 |
| House Expenses ... ... ... ... ... | 67 | 1 | 10 | | | |
| Coals and Gas ... ... ... ... ... | 53 | 18 | 11 | | | |
| Electric Light Expenses ... ... ... ... | 9 | 13 | 4 | | | |
| Furniture, Repairs, &c. ... ... ... ... | 9 | 13 | 10 | | | |
| Sundry Fittings and Repairs ... ... ... | 9 | 18 | 11 | | | |
| Sundries ... ... ... ... ... ... | 7 | 1 | 5 | | | |
| | | | | 157 | 8 | 3 |
| Illuminating Address to His Majesty ... ... | 5 | 13 | 0 | | | |
| Gold Medals ... ... ... ... ... ... | 52 | 10 | 0 | | | |
| | | | | 58 | 3 | 0 |
| Purchase of £400 Midland Railway 2½-per-cent. Debenture Stock ... ... ... ... | | | | 340 | 12 | 6 |
| Cheque-book and deductions on Cheques ... ... | | | | | 11 | 9 |
| Repayment to Assistant Secretary of amount due 1901 Jan. 1 on account of Turnor and Horrox Funds ... ... ... ... ... ... | | | | 2 | 0 | 11 |
| Balances, 1901 December 31:— | | | | | | |
| At Bankers', as per Pass-book ... ... | 101 | 8 | 4 | | | |
| " " on deposit ... ... ... | 300 | 0 | 0 | | | |
| In hand of Assistant Secretary on account of Turnor and Horrox Funds ... ... | 6 | 9 | 3 | | | |
| | | | | 407 | 17 | 7 |
| | | | | £2,150 | 14 | 8 |

## *Report of the Auditors.*

ve examined the Treasurer's accounts of receip
re for the year 1901, and have found and certifi
e correct. The cash in hand on December 31,
the balance at the bankers', &c., amount
7*d.*
g the past year the sum of £340 12*s.* 6*d.* has
n the purchase of £400 Midland Railway 2½ per
e Stock.
ooks, instruments, and other effects in the possess
y have been examined, and they appear to be
y condition.
ve laid on the table a list of the names of those F
n arrear for sums due at the last Annual G
f the Society, with the amount due against each F

sh to call the attention of the Society to the fac
now 250 compounding Fellows out of a total n
nd that in our opinion it would be conducive
of the Society that the composition fee shou

(Signed) W. B. Gibbs,
H. P. Hollis,
F. W. Levande

*Assets and Present Property of the Society, 1902 January 1.*

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Balances, 1901 December 31:— | | | | | | |
| At Bankers', as per Pass-book ... ... | 101 | 8 | 4 | | | |
| „ „ on deposit ... ... ... | 300 | 0 | 0 | | | |
| In hand of Assistant Secretary on account of Turnor and Horrox Funds ... ... ... | 6 | 9 | 3 | | | |
| | 407 | 17 | 7 | | | |
| Less due to Assistant Secretary on Petty Cash Account ... ... ... £1 19 3 | | | | | | |
| Less due to Cheques outstanding 16 19 6 | | | | | | |
| | 18 | 18 | 9 | | | |
| | | | | 388 | 18 | 10 |
| Due on account of Subscriptions:— | | | | | | |
| 1 Contribution of 5 years' standing ... ... | 10 | 10 | 0 | | | |
| 2 Contributions of 4 „ ... ... | 16 | 16 | 0 | | | |
| 10 „ 3 „ ... ... | 63 | 0 | 0 | | | |
| 18 „ 2 „ ... ... | 75 | 12 | 0 | | | |
| 61 „ 1 year's standing ... ... | 128 | 2 | 0 | | | |
| | 294 | 0 | 0 | | | |
| Less 3 Contributions paid in advance ... | 16 | 6 | 0 | | | |
| | | | | 287 | 14 | 0 |
| Due from Williams and Norgate for sales of Publications during 1901 ... ... ... ... ... ... ... | | | | 13 | 16 | 4 |
| £3,400 East Indian Railway 3-per-cent. Debenture Stock, including the Turnor Fund, the Horrox Memorial Fund, the Lee and Janson Fund, and the Hannah Jackson (née Gwilt) Fund. | | | | | | |
| £3,200 London and North Western Railway 3-per-cent. Debenture Stock. | | | | | | |
| £4,000 Midland Railway 2½-per-cent. Debenture Stock. | | | | | | |
| £1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock. | | | | | | |
| £1,100 Commercial Gas Company 4½-per-cent. Debenture Stock. | | | | | | |
| £1,250 Metropolitan 3-per-cent. Stock. | | | | | | |
| £932 19 0 Metropolitan 2½-per-cent. Stock. | | | | | | |
| Astronomical and other Manuscripts, Books, Prints, and Instruments. | | | | | | |
| Furniture, &c. | | | | | | |
| Stock of Publications of the Society. | | | | | | |
| Five Gold Medals. | | | | | | |

hand of volumes of the *Memoirs*:—

| At Society's Rooms | At Williams & Norgate's | Vol. | At Society's Rooms | At W & N |
|---|---|---|---|---|
| 8 | ... | XXXII. | 145 | |
| 42 | ... | XXXIII. | 154 | |
| 51 | 3 | XXXIV. | 156 | |
| 16 | 3 | XXXV. | 104 | |
| 65 | 1 | XXXVI. | 187 | |
| 82 | 1 | XXXVII. Part 1 | 330 | |
| 77 | 3 | XXXVII. Part 2 | 278 | |
| 89 | 3 | XXXVIII. | 263 | |
| 100 | 3 | XXXIX. Part 1 | 228 | |
| 117 | 6 | XXXIX. Part 2 | 233 | |
| 140 | 3 | XL. | 248 | |
| 124 | 3 | XLI. | 392 | |
| 130 | 3 | XLII. | 224 | |
| 142 | ... | XLIII. | 221 | |
| 147 | ... | XLIV. | 205 | |
| 152 | ... | XLV. | 238 | |
| 150 | ... | XLVI. | 214 | |
| 358 | ... | XLVII. Part 1 | 2 | |
| 131 | ... | | | |

Stock in hand of volumes of the *Monthly Notices*:—

| Vol. | At Society's Rooms | At Williams & Norgate's | Vol. | At Society's Rooms | At Williams & Norgate's |
|---|---|---|---|---|---|
| I. | 53 | ... | XXXIII. | 86 | ... |
| II. | 55 | ... | XXXIV. | 65 | 1 |
| III. | ... | ... | XXXV. | 51 | ... |
| IV. | ... | ... | XXXVI. | 25 | 1 |
| V. | ... | ... | XXXVII. | 31 | 3 |
| VI. | 40 | ... | XXXVIII. | 95 | 1 |
| VII. | 2 | ... | XXXIX. | 95 | ... |
| VIII. | 151 | 2 | XL. | 103 | 3 |
| IX. | 23 | 3 | XLI. | 103 | 5 |
| X. | 170 | 1 | XLII. | 111 | 1 |
| XI. | 181 | ... | XLIII. | 108 | 2 |
| XII. | 104 | 1 | XLIV. | 110 | 2 |
| XIII. | 176 | 2 | XLV. | 114 | 1 |
| XIV. | 175 | 3 | XLVI. | 107 | ... |
| XV. | 167 | 2 | XLVII. | 122 | 2 |
| XVI. | 152 | 1 | XLVIII. | 117 | ... |
| XVII. | 164 | ... | XLIX. | 108 | 7 |
| XVIII. | 242 | ... | L. | 108 | 9 |
| XIX. | 51 | ... | LI. | 110 | 6 |
| XX. | 31 | ... | LII. | 107 | 10 |
| XXI. | 16 | ... | LIII. | 111 | 13 |
| XXII. | 30 | ... | LIV. | 109 | 13 |
| XXIII. | 17 | ... | LV. | 122 | ... |
| XXIV. | 22 | ... | LVI. | 120 | 2 |
| XXV. | 13 | ... | LVII. | 127 | 2 |
| XXVI. | 9 | ... | LVIII. | 124 | ... |
| XXVII. | 3 | ... | LIX. | 129 | 3 |
| XXVIII. | 70 | ... | LX. | 133 | 4 |
| XXIX. | 50 | ... | LXI. | 150 | ... |
| XXX. | 61 | 2 | 1st Index ... | 541 | 1 |
| XXXI. | 90 | ... | 2nd „ ... | 796 | ... |
| XXXII. | 106 | 5 | | | |

| | | |
|---|---|---|
| Library Catalogue ... ... ... ... | 540 | 2 |
| „ „ Supplement ... ... | 422 | ... |

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly

all the volumes. With the exception, however, of Vols. XXXVI. to LXI., no complete volumes can be formed from the separate numbers in stock.

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## *Celestial Photographs.*

The following is a list of reproductions of Celestial Photographs published by the Royal Astronomical Society for sale to the Fellows :—

| R.A.S. Ref. No. | Subject. | Photographed by |
|---|---|---|
| 1 | Total Solar Eclipse, 1889 January 1 | W. H. Pickering |
| 2 | Total Solar Eclipse, 1893 April 16 | J. M. Schaeberle |
| 3 | Total Solar Eclipse, 1886 August 29 | A. Schuster |
| 4 | Nebulæ in the *Pleiades* | Isaac Roberts |
| 5 | Nebula M 74 *Piscium* | Isaac Roberts |
| 6 | Great Nebula in *Orion* | Isaac Roberts |
| 7 | Milky Way near M 11 | E. E. Barnard |
| 8 | Milky Way near Cluster in *Perseus* | E. E. Barnard |
| 9 | Comet *c* 1893 IV. (Brooks), 1893 October 21 | E. E. Barnard |
| 10 | Comet *a* 1892 I. (Swift), 1892 April 7 | E. E. Barnard |
| 11 | Nebula about $\eta$ *Argûs* | David Gill |
| 12 | Portion of Moon (Hyginus-Albategnius) | Lœwy and Puiseux |
| 13 | Comet *c* 1893 IV. (Brooks), 1893 October 22 | E. E. Barnard |
| 14 | Comet *c* 1893 IV. (Brooks), 1893 October 20 | E. E. Barnard |
| 15 | Comet *c* 1893 IV. (Brooks), 1893 November 10 | E. E. Barnard |
| 16 | Comet *a* 1892 I. (Swift), 1892 April 26 | E. E. Barnard |
| 17 | Comet *f* 1892 III. (Holmes), 1892 November 10 | E. E. Barnard |
| 18 | Comet *a* 1892 I. (Swift), 1892 April 18 | E. E. Barnard |
| 19 | Portion of Moon (Alps, Apennines, &c.) | Lœwy and Puiseux |
| 20 | Nebula in *Andromeda* | Isaac Roberts |
| 21 | *Jupiter*, 1892 September 26 | Lick Observatory |
| 22 | Cluster M 13 *Herculis* | W. E. Wilson |
| 23 | Total Solar Eclipse, 1893 April 16 (5 sec.) | J. Kearney |
| 24 | Total Solar Eclipse, 1893 April 16 (20 sec.) | J. Kearney |
| 25 | The Moon (Age $7^d\ 3^h$) | Lick Observatory |
| 26 | The Moon (Age $12^d\ 6\frac{1}{2}^h$) | Lick Observatory |
| 27 | The Moon (Age $16^d\ 18^h$) | Lick Observatory |
| 28 | The Moon (Age $23^d\ 8^h$) | Lick Observatory |

| R.A.S. Ref. No. | Subject. | Photographed by |
|---|---|---|
| 29 | The Sun, 1892 February 13 | Roy. Obs., Greenwich |
| 30 | The Sun, 1892 July 8 | Roy. Obs., Greenwich |
| 31 | Portion of Moon (Region of Maginus) | Lœwy and Puiseux |
| 32 | The Moon (Age $14^d\ 1^h$) | Lick Observatory |
| 33 | Portion of Moon (Ptolemæus, &c.) | Lick Observatory |
| 34 | Portion of Moon (Mare Serenitatis) | Lick Observatory |
| 35 | Portion of Moon (Clavius, Licetus, &c.) | Lick Observatory |
| 36 | Portion of Moon (Regiomontanus, &c.) | Lick Observatory |
| 37 | Portion of Moon (Tycho, Thebit, &c.) | Lick Observatory |
| 38 | Portion of Moon (Theophilus, &c.) | Lick Observatory |
| 39 | Total Solar Eclipse, 1896 August 9 (3 sec.) | S. Kostinsky |
| 40 | Total Solar Eclipse, 1896 August 9 (26 sec.) | A. Hansky |
| 41 | Cluster M 56 *Lyræ* | |
| 42 | Nebulæ M 81, 82 *Ursæ Majoris* | |
| 43 | Cluster M 56 *Lyræ* (enlarged) | |
| 44 | Solar Corona, 1871 December 12, Baikul | H. Davis |
| 45 | Solar Corona, 1875 April 6, Siam | Lockyer and Schuster |
| 46 | Solar Corona, 1878 July 29, Wyoming | W. Harkness |
| 47 | Solar Corona, 1882 May 17, Egypt | Abney and Schuster |
| 48 | Solar Corona, 1883 May 6, Caroline Island | Lawrance and Woods |
| 49 | Solar Corona, 1885 September 9, Wellington, N.Z. | Radford |
| 50 | Solar Corona, 1886 August 29, Grenada, W.I. | A. Schuster |
| 51 | Solar Corona, 1887 August 19, Japan | M. Sugiyama |
| 52 | Solar Corona, 1889 January 1, California | W. H. Pickering |
| 53 | Solar Corona, 1889 December 22, Cayenne | J. M. Schaeberle |
| 54 | Solar Corona, 1893 April 16, Fundium | J. Kearney |
| 55 | Solar Corona, 1893 April 16, Brazil | A. Taylor |
| 56 | Great Nebula in *Orion* | W. E. Wilson |
| 57 | Dumb-bell Nebula, *Vulpecula* | W. E. Wilson |
| 58 | Spiral Nebula, *Canes Venatici* | W. E. Wilson |
| 59 | Spiral Nebula, *Canes Venatici* (enlarged) | W. E. Wilson |
| 60 | Annular Nebula, *Lyra* | W. E. Wilson |
| 61 | Meteor Trail and Comet Brooks, 1893 November 13 | E. E. Barnard |
| 62 | Total Solar Eclipse, 1898 January 22 (5 sec.) | W. H. M. Christie |
| 63 | Total Solar Eclipse, 1898 January 22 (20 sec.) | W. H. M. Christie |
| 64 | Solar Corona, 1896 August 9, Novaya Zemlya | G. Baden-Powell |
| 65 | Solar Corona, 1898 January 22, Pulgaon, India | E. H. Hills |
| 66 | Nebula in *Andromeda* | Roy. Obs., Greenwich |
| 67 | Spectrum of Sun's limb, 1898 January 22 | E. H. Hills |

| R.A.S. Ref. No. | Subject. | Photographed by |
|---|---|---|
| 68 | Annular Nebula, *Lyra* | Lick Observatory |
| 69 | Dumb-bell Nebula, *Vulpecula* | Lick Observatory |
| 70 | Spiral Nebula, *Canes Venatici* | Lick Observatory |
| 71 | Spiral Nebula, *Ursa Major* | Lick Observatory |
| 72 | Trifid Nebula, *Sagittarius* | Lick Observatory |
| 73 | Great Nebula in *Orion* | Lick Observatory |
| 74 | Cluster M 13 *Herculis* | Lick Observatory |
| 75 | Solar Surface with Faculæ | G. E. Hale |
| 76 | Faculæ and Prominences | G. E. Hale |
| 77 | Total Solar Eclipse, 1898 Jan. 22 (⅔ sec.) | W. H. M. Christie |
| 78 | Nebula H V. 14 *Cygni* | W. E. Wilson |
| 79 | Portion of Moon (Theophilus, &c.) | Yerkes Observatory |
| 80 | Total Solar Eclipse, 1900 May 28 (30 sec.) | E. E. Barnard |
| 81 | Comet 1901 I., 1901 May 4 | Roy. Obs., Cape of G. H. |
| 82 | Comet 1901 I., 1901 May 6 | Roy. Obs., Cape of G. H. |
| 83 | Comet 1901 I., 1901 May 9 | Perth Obs., W. Australia |
| 84 | Solar Surface with Faculæ | H. Deslandres |
| 85 | Solar Prominences | H. Deslandres |

Nos. 44-55 and Nos. 64 and 65 form a series of corona photographs, oriented and reduced to the same scale.

The above photographs are now on sale to Fellows as prints, either platinotype or aristotype, mounted on sunk cut-out mounts, measuring 12 inches by 10 inches, and also as lantern slides. Nos. 44-55 and Nos. 64 and 65 are also supplied as transparencies, 6¼ inches square.

Price of prints, 1*s.* 6*d.* each; lantern slides, 1*s.* each; packing and postage extra.

Unmounted prints, 1*s.* each, can be obtained to order.

Transparencies, 6¼ inches square (Nos. 44-55 and Nos. 64 and 65), 3*s.* 6*d.* each.

Orders to be addressed to W. H. Wesley, Burlington House, London, W. In ordering prints or slides the R.A.S. Reference No. only need be quoted, but in the case of prints it should be stated whether platinotypes or aristotypes are required.

*Instruments belonging to the Society.*

A brief description of the chief instruments and other particulars relating to them will be found in *Monthly Notices*, vol. xxxvi. p. 126.

No. 1. The *Harrison* clock.
„ 2. The *Owen* portable circles, by Jones.
„ 3. The *Beaufoy* circle.
„ 4. The *Beaufoy* transit instrument.
„ 5. The *Herschel* 7-foot telescope.
„ 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Utzschneider and Fraunhofer, of Munich.
„ 7. The *Smeaton* equatorial.
„ 8. The *Cavendish* apparatus.
„ 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
„ 10. The variation transit instrument (late Mr. Shearman's).
„ 11. The universal quadrat, by Abraham Sharp.
„ 12. The *Fuller* theodolite.
„ 13. The standard scale, by Troughton and Simms.
„ 14. The *Beaufoy* clock, No. 1.
„ 15. The *Beaufoy* clock, No. 2.
„ 16. The *Wollaston* telescope.
„ 17. The *Lee* circle.
„ 18. The *Sharpe* reflecting circle.
„ 19. The *Brisbane* circle.
„ 20. The *Baker* universal equatorial.
„ 21. The *Reade* transit.
„ 22. The *Matthew* equatorial, by Cooke.
„ 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A sextant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.

The *Sheepshanks* collection :—

„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumb-line; portable clamping foot and tripod stand.
„ 29. (3) Equatorial stand and clock movement for $4\frac{6}{10}$-inch telescope (telescope lost); double-image micrometer; two wire micrometers; object-glass micrometer.
„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

No. 31. (5) 2¾-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

„ 33. (7) 2-foot navy telescope.

„ 34. (8) Transit instrument of 45 inches focal length, with iron stand and also Y's for fixing to stone piers; two axis levels.

„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.

„ 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.

„ 37. (11) Portable zenith telescope and stand, 2¾-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, reading to 10″ by two verniers to each circle.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, 2⅛-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end, reading to single minutes; horizontal circle 9 inches diameter in brass to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y-piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass 1⅝-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator, with object-glass 1⅞-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon, with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

„ 46. (20) Reflecting circle, by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.

No. 47. (21) Box sextant; reflecting plane and level.
„ 48. (22) Prismatic compass, by Troughton and Simms.
„ 49. (23) Mountain barometer.
„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.
„ 51. (25) Ordinary 4½-inch compass with needle.
„ 52. (26) Dipping needle, by Robinson.
„ 53. (27) Compass needle, mounted for variation.
„ 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen; a strongly fitted brass box with heavy magnet; filar suspension.
„ 55. (29) Box of magnetic apparatus.
„ 56. (30) Hassler's reflecting circle, by Troughton; a 10½-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices; four verniers reading to 10″.
„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.
„ 58. (32) Plane 2⅜-inch speculum, artificial horizon and stand.
„ 59. (33) 2½-inch circular level horizon, by Dollond.
„ 60. (34) Artificial horizon, roof, and trough; the trough 8¼ by 4½ inches; tripod stand.
„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square; one beam compass.
„ 62. (36) A pantograph.
„ 63. (37) A noddy.
„ 64. (38) A small Galilean telescope with object-glass of rock crystal.
„ 65. (39) Five levels.
„ 66. (40) 18-inch celestial globe.
„ 67. (41) Varley stand for telescope.
„ 69. (43) Telescope, with object-glass of rock crystal.
„ 71. Portable altazimuth tripod.
„ 72. Four polarimeters.
„ 74. Registering spectroscope, with one large prism.
„ 76. Two five-prism direct-vision spectroscopes.
„ 78. 9¼-inch silvered-glass reflector and stand, by Browning.
„ 79. Spectroscope.
„ 80. A small box, containing three square-headed Nicol's prisms; two Babinet's compensators; two double-image prisms; three Savarts; one positive eyepiece, with Nicol's prism; one dark wedge.
„ 81. A back-staff, or Davis' quadrant.
„ 82. A nocturnal or star dial.
„ 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.
„ 84. A Hollis observing chair.
„ 85. Double-image micrometer, by Troughton and Simms.

No. 86. 4½-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.
„ 87. 3¼-inch Gregorian reflecting telescope with wooden tripod stand.
„ 88. Pendulum, with 5-foot brass suspension rod, working on knife-edges, by Thomas Jones.
„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.
„ 90. An Arabic celestial globe of bronze, 5¾ inches in diameter.
„ 91. Astronomical time watch-case, by Professor Chevallier.
„ 92. 2-foot protractor, with two movable arms, and vernier.
„ 93. Beam compass, in box.
„ 94. 2-foot navigation scale.
„ 95. Stand for testing measures of length.
„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position angles.
„ 97. 12-cell Leclanché battery.
„ 98. 2-foot 6-inch navy telescope, with object-glass 2½ inches, by Cooke, with portable wooden tripod stand.
„ 99. 12-inch transit instrument, by Fayrer and Son, with level and portable stand.
„ 100. 9-inch transit instrument, with level and iron stand.
„ 101. Small equatorial sight instrument, by G. Adams, London.
„ 102. Sun-dial, by Troughton.
„ 103. Sun-dial, by Casella.
„ 104. Sun-dial.
„ 105. Box sextant, by Troughton and Simms.
„ 106. Prismatic compass, by Schmalcalder, London.
„ 107. Compass, by C. Earle, Melbourne.
„ 108. Prismatic compass, by Negretti and Zambra.
„ 109. Dipleidoscope, by E. Dent.
„ 110. Abney level, by Elliott.
„ 111. Pocket spectroscope, by Browning.
„ 112. Universal sun-dial.
„ 113. Double sextant, by Jones.
„ 114. Two models, illustrating the effects of circular motions.
„ 115. A cometarium.
„ 117. Two old sun-dials.
„ 118. A 10½-inch sixteenth-century celestial globe, on bronze tripod stand.
„ 119. Specimens of diffraction gratings, by Prof. W. A. Rogers.
„ 120. A 6-prism spectroscope, by Browning.
„ 121. Spitta's improved maximum and minimum thermometer.

No. 122. A 6-inch speculum, with flat; the speculum said to be by Sir W. Herschel, and re-figured by Sir J. Herschel.
„ 123. A 6-inch refracting telescope, by Grubb, with 3 eyepieces.
„ 124. Position micrometer, by Cooke.
„ 125. A 6-inch refracting telescope, by Simms, with eyepieces and solar diagonal.
„ 126. 3½-inch portable refracting telescope, by Tulley, with tripod stand.
„ 127. Globe representing the visible surface of the Moon, by John Russell, R.A. (1797).
„ 128. Bichromate battery and Ruhmkorff coil.
„ 129. Slater's improved armillary sphere.
„ 130. 10-inch brass pillar sextant with counterpoise stand, by Troughton.
„ 131. Double box sextant, by Cary.
„ 132. Equatorially mounted camera with 2½-inch portrait lens and telephotographic enlarging lens by Dallmeyer; iron pillar.
„ 133. 3½-inch equatorial by Ross, with tall tripod stand, equatorial mounting, eyepieces, and micrometer.
„ 134. Old transit instrument, 2-inch aperture and 3 feet focal length (without stand), formerly belonging to Dr. Longfield, of Cork.
„ 135. Globe of Mars, by E. M. Antoniadi.
„ 136. A small universal instrument by W. and S. Jones, London; the telescope 1½-inch aperture and 15 inches focal length. [Presented by Miss Moore.]
„ 137. Polar siderostat by Hilger, with 4⅛-inch mirrors. [Presented by Mr. Alexr. Foote.]
„ 138. Transit instrument, aperture 2¾-inch, with collimator and stand. [Presented by Mrs. Cross.]
„ 139. Transit instrument, aperture 1 11/12-inch, with portable stand. [Presented by Mrs. Cross.]
„ 140. 3¼-inch object-glass and tube. [Presented by Mrs. Cross.]

Besides the above, there is the following apparatus available for eclipse work:—

4 Slits for spectroscope.
Abney doublet lens used in photographing the corona.
2 Dallmeyer negative enlarging lenses.
Cœlostat with 16-inch plane mirror.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons:—

No. 4. The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.

e *Matthew* equatorial, to Mr. C. Thwaites.
e *Matthew* transit, to Captain W. Noble.
nch theodolite and stand, to Dr. A. A. Common.
uatorial mounting, clock, &c., to the Rev. C. D. P. Davies.
ire micrometer (No. 2), to the Rev. C. D. P. Davies.
-inch equatorial and stand, to Mr. C. H. Johns.
uble-image micrometer, to the Rev. W. J. B. Roome.
x sextant, to Dr. A. A. Common.
escope with rock-crystal object-glass, to Sir W. Huggins.
larimeter, to Professor C. Michie Smith.
-inch reflector and stand, to the Rev. W. J. B. Roome.
x of polariscopic apparatus, to Mr. H. F. Newall.
oot 6-inch navy telescope, to the Rev. J. M. Bacon.
nch telescope, by Grubb (object-glass only), to Mr. W. E. Wilson.
nch refractor, by Simms, to Dr. A. A. Common.
-inch equatorial, by Ross, to Dr. A. W. Roberts.

*Award of Medals.*

Royal Society. The Council of the Royal Society have also further kindly arranged that notice be sent to the Royal Astronomical Society as soon as papers which might be required are in type, so that the additional copies for the Appendices to the *Memoirs* or *Monthly Notices* can be obtained before the type is distributed, the Royal Astronomical Society paying for the cost of striking off the additional copies.

During the past year four numbers of Appendix to vol. lxi. of the *Monthly Notices* have been published, containing, amongst others, a series of papers on *Nova Persei*, by Sir Norman Lockyer; and one Appendix to vol. lxii., containing the preliminary reports of the observers of the total solar eclipse of 1901.

The following Appendices to vol. liv. of the *Memoirs* have also been issued:

I. Sir Norman Lockyer, Total eclipse of the Sun, 1898 January 22; observations at Viziadrug.

II. J. Evershed, Wave-length determinations and general results obtained from a detailed examination of spectra photographed at the solar eclipse of 1898 January 22.

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*Address to His Majesty.*

The Council have pleasure in announcing that His Majesty King Edward VII. was graciously pleased to accept the Address of condolence and homage, the text of which was printed on p. 181 of last year's Annual Report. The Address was presented by the President and Secretary, and was received by His Majesty in person at St. James's Palace on March 20, 1901.

On April 18 a letter was received by the President from General Sir D. Probyn, Keeper of H.M. Privy Purse, announcing that His Majesty had graciously consented to become the Patron of the Society.

## Obituary.

regret that they have to record the loss by death
gracious Patron Her late Majesty Queen Victoria
lowing Fellows and Associates during the past

llows :—Rev. J. Chadwick Bates.
E. E. Bowen.
*John Brett.
Rev. R. Crowe.
Major-Gen. A. W. Drayson.
J. P. Hartree.
Lord Inverclyde.
S. Wellesley Johnson.
William Lethbridge.
†D. L. Lowson.
Charles Meldrum.
John Parnell.
Sir Cuthbert E. Peek.
B. Woodd Smith.

Mr. Bates took a deep interest in several branches of science, particularly astronomy, meteorology, and geology. He had a well-equipped meteorological station in the vicarage garden and kept a careful record of the rainfall, temperature, &c. He was a Fellow of the Geological Society as well as of the Royal Astronomical Society, to which he was elected on the 13th of November 1863. Mr. Bates possessed considerable mechanical skill, and constructed almost entirely with his own hand the dome over his equatorial. He built a room for his transit instrument himself, and he also carved parts of the stonework of the church.

Mr. Bates married a Miss Jackson, of Hull, who died in 1874. They had one son and four daughters. He died on the 14th of December 1901, at St. Martin's Vicarage after a short illness.

Edward Ernest Bowen was born in 1836, being the second son of the Rev. Christopher Bowen, sometime Vicar of St. Thomas's, Winchester; his elder brother was the late Lord Bowen, the well-known Judge. Edward Bowen went up from King's College, London, to Trinity College, Cambridge, in 1854; he was a Bell Scholar for 1855. In 1858 he was fourth in the Classical Tripos, and shortly afterwards obtained a Fellowship at Trinity. He left Cambridge soon after to become a master at Harrow, where the rest of his life was spent unreservedly and whole-heartedly for the welfare of the school and in the service of his pupils. His brilliant intellect, sound judgment, and unlimited kindness made him an ideal schoolmaster.

Many who have never seen him have been charmed by his school songs. "Forty Years On" has long been classical, and is known far beyond the bounds of Harrow.

A typical Bowenite institution at Harrow was "astronomy." Every boy in his house had to attend two courses of lectures before he left—one astronomy, the other the history of a war—but both were called by the boys "astronomy." Each Christmas term, for one evening in every week, the astronomers (roughly speaking, the middle-sized boys of the house) were gathered in his drawing room, and, if it was astronomy proper, he explained the courses of the heavens by aid of a little round table that was the Sun, a cricket-ball that was the Moon, putting them through their various motions in the centre of the room. Sometimes he himself actively personified the Moon or some other heavenly body, while the boys sat round critically spectatorial. The boys had no function but to look on, but evil waited on him who did not understand and remember.

Mr. Bowen died on the 8th of April at Moux, in the Côte-d'Or, France, while on a bicycling tour. He was to all appearance in perfect health, but fell while mounting his machine and never recovered consciousness.

He was elected a Fellow of the Astronomical Society on the 8th of February 1867.

RT was born at Reigate on the 8th of December
as an artist of eminence, and was elected an
he Royal Academy in 1881. "In early life"
*Times* of the 9th of January) "he came strongly
uence of the Pre-Raphaelite movement. Over an
f his, *The Stonebreaker*, Ruskin grew enthusiastic.
ellous picture,' he wrote, 'and may be examined
ith delight;' and again, 'I know no such thistle-
chalk hills and elm trees, no such natural pieces
loud.' This picture was exhibited at the Royal
1858. In the following year Brett showed his
*l'Aosta*, in which he endeavoured, not without
rry out the principles of the pre-Raphaelites in
ting. Very few artists have tried to do this,
n Hunt, in addition to Brett, showed that the
hool could be illustrated by landscape as well as
gure pictures." Perhaps the most famous of the
of sea and coast scenery which he painted later
*nnia's Realm*, a simple stretch of open sea, which
scinated the attention; it was exhibited at the
y in 1880, and purchased by the Trustees of the
uest. He continued to paint and exhibit up to the
f his life, and died at the ripe age of 70 on the
y 1902.

was a devoted astronomer throughout his life. "I
about thirteen or fourteen years old," writes his
en he *bought* his first telescope, and that was a
r. I remember it well. Before that time he had

. . . . I must confess I was extremely vexed not to see anything like the corona I expected ; I should never have called this a corona at all. . . . . There were certainly no streamers, so I conclude they must have been intercepted by the cloud. I do not mean merely that their light was, but their cause also. . . . . I conclude that the dew which would have formed streamers was, at Augusta, intercepted or prevented by cloud ; although the latter was not dense enough to conceal much." (*Monthly Notices*, xxxi., pp. 165-6.) We now know that this conclusion as to the terrestrial nature of the streamers was incorrect ; but Mr. Brett, no doubt, recorded very faithfully what he saw. His trained eye was a most effective astronomical weapon, and his actual observations are deserving of every respect, though when he proceeded to draw deductions he is more open to criticism.

At this same eclipse he noticed a "ray or cone of light emanating from the south (later, also the north) cusp in a direction tangential to the Moon's limb, length not more than 3′ : light less intense than that of the cusp, but as beautifully defined as anything I ever saw in my life." At the partial eclipse on the 10th of October 1874 he saw the same phenomenon on a much smaller scale, and made the suggestion of a lunar atmosphere, which is only of appreciable density in the deepest valleys. This is not the place to discuss the conclusion, but the observations are well worthy of note ; as also those from which Mr. Brett concluded that indications of the corona could be seen without an eclipse (*Monthly Notices*, xxxii., 297).

His other observations (made at his residence at Putney, chiefly with the Browning reflector above mentioned, for which he devised a simple but firm altazimuth mounting, though he had, also, the Matthew Equatorial on loan from this Society for many years) were of planetary detail, and called attention to several points of great importance. He observed that the white spots on *Jupiter* were either themselves shaded or cast a shadow, and concluded that "neither the dark belts nor the bright ones are opaque, and that if *Jupiter* has any nucleus at all it is not visible to us." He observed that the brightest point of the disc of *Venus* was not at the limb, but sensibly within the limb, indicating that there was specular reflection from its surface largely modified by atmospheric diffusion. And, finally, he observed shadows cast by the polar caps of *Mars*, and concluded that they were not snow, but cloud.

These observations met with almost a storm of incredulity in some quarters when communicated to the Society. "One is tempted to ask," wrote the late Mr. R. A. Proctor to the *Astronomical Register* (vol. xv., page 45), "what is coming to the Royal Astronomical Society when such a paper as Mr. Brett's, on the bright ring seen round *Venus* during transit, is allowed by the Council to be read before a meeting of the Fellows ? . . . All that the spectroscope has taught us, all that we have learned of meteoric and cometic systems and of the laws of cosmical

ıws of optics, and in fine the teachings of every modern astronomy, seem of no weight whatever lent artist whose paintings of Scilly scenery much a year or so since. Not content with ıa in the full blaze of sunlight, and setting globes Earth bobbing in the atmosphere of *Jupiter*, he ıstronomers to look during the transit of *Venus* mage of the Earth reflected in *Venus's* looking- ıext? and next?" They were times when views with considerable frankness within the Society; himself, it may be acknowledged, was one of e his mind most directly. But those who, instead ı observation because it announced a new fact, e to test it by observation themselves, generally Brett's keen sight had not misled him. The ›mer Royal tested the announcement of specular *Venus* by an independent method with the 13-inch and verified it; and he followed Mr. Brett tion of the bright ring seen round *Venus* in to specular reflection modified by atmospheric observations on *Mars* have been corroborated, tly interpreted; for other observers have seen to the caps and called it melted snow. The by white spots on *Jupiter* were confirmed paper read to the French Academy in 1876; s seeing the corona in daylight, M. Tacchini n more remarkable observation in 1879 (*Obser-* page 423). Recently more attention has been

painted in 1880, he shows how the Sun may be painted the right size (usually it is grossly exaggerated in pictures) and yet produce the right effect on the casual observer. He made a sketch of the great comet of 1882, which was reproduced in the *Monthly Notices* (vol. xliii., page 288); and a "rough drawing of *Copernicus*," made with the Matthew Equatorial in 1876, forms the frontispiece to vol. i. of the *Observatory*. H. H. T.

ROBERT CROWE was born at Middleton, in the Yorkshire Wolds, on the 19th of December 1820. He obtained the degree of Master of Arts at Trinity College, Dublin, and shortly afterwards took Holy Orders. For 47 years, from 1851 to 1898, he was Vicar of Woodhouse, near Huddersfield. He made his own telescopes and was a regular observer of the planets. He became a Fellow of the Society in 1869.

He married a daughter of the Rev. C. Drawbridge, a former vicar of Honley, near Huddersfield. They had no children. He died at Woodhouse Vicarage on the 9th of November 1901.

ALFRED WILLIAM DRAYSON was born at Waltham Abbey, Essex, in 1827. He received his education at the Royal Military Academy, Woolwich, and obtained his first commission in 1846. He served in the Kaffir war in 1847, and against the insurgent Boers in 1848. In both campaigns his knowledge of the Kaffir and Zulu languages were of great service. He was appointed instructor in surveying and field works at the Royal Military Academy, Woolwich, and shortly afterwards professor of surveying and practical astronomy. During this period he was instructor to the Duke of Connaught. On returning to military duty he was appointed to command the Royal Artillery at Portsmouth. In 1876 he proceeded to India in command of his brigade, and did valuable work in the rearmament of various forts in Bengal. Upon returning to England he was promoted to the rank of General. He retired from the army in 1883, and lived at Southsea till his death on the 27th of September 1901.

General Drayson wrote a number of stories, beginning in 1858 with *Sporting Scenes among the Caffres*, and following with *Among the Zulus*, *The Gentleman Cadet*, and many others. He published books on billiards and whist, on both of which games he was an authority.

As a military writer mention may be made of his work on military surveying, which had several editions and was used as a text-book.

In his astronomical writings General Drayson went somewhat astray. In one of these he attributed what were really errors of observation to a gradual increase of the Earth's diameter; and in another he substituted a geometrical movement of the pole (which more or less accounted for the phenomena of recent years, but which was entirely empirical) for the orthodox precession,

hange in inclination of ecliptic to equator, which
al basis.
ayson was of a kindly disposition and made many
assed a long life in great activity and rendered
s to his country.
ected a Fellow of the Society on the 10th of

HARTREE was born at Lewisham on the 14th of
, and died at his residence at Cambridge on the
1. He entered at Trinity College, Cambridge, in
ned a first class in the Natural Science Tripos in
aking the degrees of M.A. and M.B. he practised
as a doctor, but retired from practice in 1875.
terest in astronomy began in 1876 and continued
possessed a 6-inch Cooke equatorial, a small
ughton and Simms, and an astronomical clock.
a Fellow of the Society in 1879, but never com-
papers. He married in April 1868 Janet, eldest
nuel Smiles, LL.D. ; his wife died in 1899. They
a daughter having died in childhood.

CLYDE, better known perhaps as Sir John Burns,
lasgow in 1829. He was the eldest son of Sir
Bart., of Wemyss Bay, and Jane, daughter of
, LL.D., of Glasgow. He was educated at
rsity, and immediately after leaving college was
his father in the business of the Cunard Steam-

W. H. Smith at Tavistock Grammar School. He went to St. John's College, Cambridge, and was 9th Wrangler in 1850. He was for some time a master at Rossall and St. Paul's Schools. In 1861 he was called to the Bar and joined the firm of W. H. Smith & Son as managing partner. In 1885 he retired from active business and went to reside in his native county of Devonshire. He took an active part in the business of the county and was High Sheriff for 1893–4. For some years he was in failing health and died on 31st of March 1901.

He was elected a Fellow of the Society on the 9th of February 1855, but has not communicated any papers to the Society.

CHARLES MELDRUM was born in 1821 at Kirkmichael, in Banffshire. He was educated at Marischal College and University, Aberdeen, and was Lord Rector's Prizeman in 1844. He entered the Bombay Education Department in 1846, and two years later was appointed Professor of Mathematics at the Royal College of Mauritius. In 1851 he founded the Meteorological Society in that Colony, and was for many years its Secretary. In 1862 he was appointed Government Observer. The principal work done at the Observatory, which was situated at Port Louis, consisted in the examination and tabulation of ships' logs. As it was surrounded by hills the locality was unsuitable for a meteorological station, and in 1863, owing to Dr. Meldrum's efforts, in which he received strong support from Sir E. Sabine, the old observatory was sold preparatory to building a new one at Pamplemousses. The foundation-stone of the new observatory, the Royal Alfred Observatory, was laid in 1870 by H.R.H. the Duke of Edinburgh. It cannot be said that the new site was very happily chosen, as the ground is marshy and fever-stricken. The Royal Alfred Observatory was provided with meteorological and magnetic instruments, a 6-inch Cooke equatorial, a 3-inch transit, and a 4-inch photoheliograph. From 1880 to 1885 sun-pictures were taken regularly on a scale of 4 inches, and from 1885 to the present time on the enlarged scale of 8 inches to the Sun's diameter.

Dr. Meldrum was more interested in meteorology than astronomy, and his principal work was in connection with the law of storms in the Indian Ocean. He discovered that the diurnal barometric variation was very regular, and that a slight deviation indicated strong disturbance at a more or less great distance. His knowledge of the prevailing winds, &c., enabled him to advise vessels proceeding from Mauritius where cyclones would be met.

The British Association Reports for 1874 and 1876 contain papers in which he tabulated the number of cyclones in the years 1856 to 1875, their duration, the distances they travelled, and the areas over which the wind blew with the force of a strong gale. He compared these with Wolf's relative sun-spot numbers, and

cyclones were fewest and least severe at a Sun-
nd the converse at a maximum. He also tabu-
ll in different years at a large number of stations
the Earth, and concluded that the total amount
ell on the Earth was above the average at times
xima and below at minima. Neither of these
as yet been sufficiently confirmed to be beyond

m was elected a Fellow of the Society on the
1870. He communicated to the Society in 1873
ar Showers seen at Mauritius."
of LL.D. was conferred on him by the University
1876, and in the same year he became a Fellow
ciety. He was made C.M.G. in 1886, and served
the Council of Government of Mauritius from
After his retirement in 1896 he lived in Edin-
e died on the 28th of August 1901.

RT PEEK, the only child of Sir William Henry
Baronet, was born on the 30th of January 1855,
to the baronetcy on the death of his father in
s educated at Eton and Pembroke College,
After leaving Cambridge he went through a
uction in astronomy and surveying, and put his
o practice in two journeys across the unfre-
of Iceland, taking regular observations of the
ude, and dip of the needle. On his return to
tablished a small observatory with a 3-inch

observing long-period variables were considerable, as the observers had to determine the magnitudes of the comparison stars. These difficulties were removed in 1890 by the publication of charts and catalogues of comparison stars for variables by the Harvard College Observatory. Observations made before the 31st of December 1890 were corrected to the Harvard data, and since then the Harvard photometric magnitudes of the comparison stars have been used. Argelander's method of observing was adopted, and each observation of a variable was made by comparison with five stars of known magnitude in the same field. To the end of 1900 6,809 observations had been made and 267 maxima and 227 minima had been determined. Papers showing the light changes of ten variables have been published, and the whole of the observations made at the Rousdon Observatory, which are of great value, will appear in a volume of the *Memoirs* of the Society. Meteorological observations were also carried on, and weekly and monthly weather reports were issued from the Rousdon Observatory.

Sir Cuthbert Peek was elected a Fellow of the Society on the 11th of January 1884.

In 1884 he married the Hon. Augusta Louisa Broderick, eldest daughter of Viscount Middleton, and he leaves two sons and four daughters. He died on the 8th of July 1901.

Basil Woodd Smith was born in London on the 9th of March 1831. He was intended by his father for the Stock Exchange, but finding the work entirely uncongenial he soon abandoned it. Placed in circumstances which permitted him to give his time and counsel where they were needed, he was able to assist a number of good causes. He lived at Hampstead, and was chairman of the bench of magistrates. He assisted the local philanthropic institutions, and was for many years chairman of the Orphan Working Schools. He was a man of strong religious views, and was largely occupied in the work of the Bible Society, attending the committee meetings with great regularity for a long period. He also took great interest in Palestine exploration, and generally in all questions of Biblical archæology.

Although a good classical scholar, his interests were scientific rather than literary. He was for many years on the board of managers of the Royal Institution, and attended the lectures with great regularity. He frequently observed with a telescope he had erected on the roof of his house, and was always ready to show it to visitors and answer the questions they put to him. He was elected a Fellow of the Society on the 10th May 1861, and till recently was a regular attendant at the meetings.

Mr. Woodd Smith was twice married, and leaves eight children.

Henry Augustus Rowland, the son of the Rev. H. A. Rowland, D.D., was born at Honesdale, Pennsylvania, on the

nber 1848. He studied engineering at the ytechnic Institute at Troy, and received the Engineer (C.E.) in 1870. For a short time he engineer. In 1871–2 he was science teacher at e, and from 1872–5 was assistant professor at 3rd of April 1876 he was appointed Professor of rector of the Physical Laboratory of the Johns rsity of Baltimore, and for twenty-five years added iversity by his own brilliant researches and by rkers he stimulated to devote themselves to the ical science.

owland's first important paper was on magnetic This work he sent to Clerk Maxwell in 1873, at he was sorry he could not communicate it to ty, as that Society was not in session, but that o the *Philosophical Magazine*, and would himself, so far away, correct the proofs. Before taking ial work he studied a little time in Berlin, and in important discovery that a moving charge of y, like a current, sets up a magnetic field. ellent determination of the mechanical equivalent h this exception his researches alternated between gnetic subjects and those spectroscopic researches nomy is so greatly indebted to him.

owland's spectroscopic work began in 1882, in published a "Preliminary Notice of Results the Manufacture and the Theory of Concave tical Purposes." It is well known how imperfect

by him and his pupils appeared in the *Astrophysical Journal* as "Tables of the Arc Spectra of the Elements."

Professor Rowland's personal character is well described in the following extract from an eloquent address by Dr. Gilman, the President of the Johns Hopkins University: "Above his keen perceptions, his logic, his adaptation of means to ends, and his marvellous concentration I must place his love of truth. He was true in all his investigations, careful to eliminate errors, to avoid misconceptions, to shrink from hasty conclusions and inferences, to be critical of other investigations, to be accurate, exact, conscientious, to spare no pains, to shrink from no efforts, to conceal no difficulties, in order that the absolute facts might be established, as far as this can be done, by limited humanity. To him science was another word for truth—not all the truth, but that amount of truth which the limited powers of man have discovered. He was a follower of Isaac Newton, picking up from the seashore a few pebbles and discerning their lessons."

Professor Rowland was a member of many learned societies in Europe and America. He was elected an Associate of the Royal Astronomical Society on the 9th of December 1898. He died at his home in Baltimore on the 16th of April 1901. His body was cremated and the ashes buried beneath his famous ruling engine.

Truman Henry Safford was born on the 6th of January 1836, at Royalton, Vermont. In extreme youth he possessed extraordinary powers of arithmetical calculation, of which an account is given in *Chambers's Edinburgh Journal* for October 1847. These powers were not in his case intuitive, but were improved by study and practice, and at a very early age he obtained a knowledge of algebra and geometry. His father wisely decided to give him a good education, and at the age of ten he was placed under the charge of Professor Everett and Professor Peirce at Harvard College. In 1854 he graduated at Harvard, and immediately obtained employment at the Observatory. He remained at Harvard College Observatory for twelve years, and during this time published a number of Elements and Ephemerides of Comets and Minor Planets in the *Astronomical Journal*, and contributed several papers to the *Monthly Notices*. The most interesting of the latter is a determination of the orbital motion of *Sirius* from the observations of declination. In 1860 he prepared a Catalogue of the Declination of 532 Stars culminating near the Zenith of the Harvard College Observatory, for use in the survey of the Great Lakes in the determination of latitude by Talcott's method. In 1865, after the death of Professor Bond, Professor Safford was for a short time in charge of the Observatory. During this time he brought out vol. iv. of the Annals, consisting of a Catalogue of Standard Right Ascensions of Clock Stars and Close Polars. He also edited

rations upon the Great Nebula of *Orion*," which
hed by Professor Bond.
fessor Safford was appointed first Director of the
rvatory at Chicago, and devoted himself to obser-
læ with the 18-inch equatorial. In consequence
of 1871, the Observatory, which was supported by
nce, could no longer be maintained, and Professor
871–1876 was obliged to leave astronomy for
or the United States Government. In the latter
ppointed Professor of Astronomy at Williams
nstown, Massachusetts, a post which he continued
death on the 13th of June 1901. Although his
ties left him but little time for research, his
progress of astronomy was maintained, especially
ment in the accuracy of right ascensions and
stars both by further observation and also by
isting star catalogues. He chose as his particular
near the North Pole, and brought out a catalogue
ensions of 133 stars within 10° of the Pole, and
he *Monthly Notices* several papers on the com-
ous catalogues in this part of the sky.
fford was a devoted and painstaking astronomer,
se of the nearly fifty years of his astronomical
plished a considerable amount of useful work.
an Associate of the Society in 1866.

WILHELM SCHUR was born at Altona on the
1846. He was a relative of Dr. Petersen, the

investigated the errors of the instrument with the utmost care and executed three very laborious triangulations—*Praesepe*, *h Persei*, and $\chi$ *Persei*—work which was planned and begun, if not finished, before the advantages of photography for this class of observations was generally appreciated.

In co-operation with Dr. Gill he made extensive triangulations of the comparison stars of *Victoria*, *Iris*, and *Sappho*, and many observations of these planets at their oppositions in 1889 for the determination of the solar parallax. Under Professor Schur's direction a re-reduction of Olbers' Comet Observations was made by Dr. Stichtenoth was made in 1898, and appears as a supplement to Schilling's *Life of Olbers*.

Professor Schur died on the 1st of July 1901, at the age of fifty-five, after a long and severe illness. His whole life was spent with unremitting industry in the service of astronomy. He was elected an Associate on the 9th of December 1898.

85 are generally third companions of close pairs
ccount of the difference of magnitude.
d rapid binaries are kept under constant obser-
s all the difficult stars observable in this latitude,
e telescope is required. The following list gives
rs measured during the year :—

| Mags. | Dist. | Star. | Mags. | Dist. |
|---|---|---|---|---|
| | " | | | " |
| 7·2 , 7·5 | 0·1 | 42 Comæ | 5·5 , 5·9 | 0·3 |
| 6·0 , 7·0 | 0·2 | $\gamma^2$ Androm. | 5·0 , 6·2 | 0·3 |
| 7·0 , 7·0 | 0·2 | Σ 234 | 7·0 , 7·4 | 0·3 |
| 7·0 , 7·5 | 0·2 | OΣ 225 | 5·2 , 11·2 | 0·8 |
| 3·5 , 6·0 | 0·2 | Aldebaran | 1 , 14 | 31·4 |
| 3·5 , 3·9 | 0·2 | $\beta$ 733 | 6·0 , 11·0 | 0·7 |

good series of observations have been obtained

| Mags. | Dist. | Star. | Mags. | Dist. |
|---|---|---|---|---|
| | " | | | " |
| 3·9 , 5·0 | 0·1 | $\zeta$ Herculis | 3·0 , 6·5 | 0·9 |
| 7·0 , 7·0 | 0·1 | 70 Ophiuchi | 4·1 , 6 1 | 1·5 |
| 4·5 , 5·0 | 0·1 | | | |

ations of *Capella* as a double star have been con-
y favourable opportunity during the year and a

comparison spectra taken at the beginning and end of the exposure in different positions of the instrument. With a view to remedying this, the collimators and camera have been more firmly clamped and all parts examined to guard against possibility of shift. The spectroscopic observations were temporarily discontinued at the end of November, the reflector being in use for photographing the nebulosity round the *Nova*.

*Astrographic Equatorial.*—566 plates have been taken during the year on 139 nights. Of these, 56 have been rejected—viz. 12 because the exposure was interrupted by cloud or the plate did not come up to the standard in showing faint stars, 15 on account of fault of guiding or setting, 18 owing to photographic, and 11 for miscellaneous defects. Of the 510 successful plates, 128 were of *Eros*; 153 of *Nova Persei* and field, and 100 of the *Nova* and neighbouring stars of approximately the same magnitude; 87 for the chart, 36 for the catalogue and 6 for adjustment of the equatorial. The number of successful fields taken during the year is 82 for the chart and 34 for the catalogue. These photographs have been taken to replace some of the poorer photographs already taken. Successful photographs of more than 1,100 fields out of the 1,149 required are on the shelves. During the year 1901 positives on glass of 144 chart plates were made, which brings the total number to 1,254, of which 150 are duplicates.

During the year 1901, 112 plates were measured, both in direct and reversed positions of the plate, by two measurers, who measured the $6^m$ and $3^m$ images respectively. The measurement is now completed for the Greenwich zones from Dec. $+64°$ to Dec. $+76°$, and to Dec. $+77°$, as far as $20^h$, making a total of 800 plates out of 1,149, or 1,545 square degrees out of 2,088.

The measures of 210 plates have been printed during the year. All the measures between Dec. $+64°$ and Dec. $+71°$ are now in type, corresponding to 478 plates covering 964 square degrees. The number of stars measured in this area is 68,922, or rather more than 71 per square degree.

The number of stars shown with $40^m$ exposure has been counted on 162 chart plates during the year. The counting up to the present time has been completed for the area from Dec. $+65°$ to Dec. $+69°$, and to Dec. $+70°$ as far as $6^h$, or for about 320 plates, covering 600 square degrees.

The following table, in continuation of one given last year, gives the number of stars in Zones 67°, 68°, and 69° from $0^h$ to $6^h$, obtained with exposures of $40^m$, $6^m$ and $3^m$, and $20^s$, compared with the numbers given in the B.D., and the number given in that work down to $9^m{\cdot}0$. The first line for each zone gives the total number of stars shown, and the second line the number of stars shown twice—*i.e.* on each of the overlapping series of plates. The totals refer to all the plates counted up to the present time, Zones 65° to 69°.

| Number in B.D. $9^{m}\cdot0$ and brighter. | Number in B.D. Total number. | Number shown on Photographs Exposure 20s. | Exposure 3m and 6m. | Exposure 40m. |
|---|---|---|---|---|
| 624 | 1,577 | 1,849 | 9,587 | 44,489 |
| | | 1,201 | 7,236 | 39,188 |
| 529 | 1,470 | 2,103 | 9,939 | 45,553 |
| | | 1,277 | 8,006 | 40,947 |
| 148 | 364 | 650 | 2,763 | 15,272 |
| | | 346 | 2,250 | 13,133 |
| 2,695 | 7,160 | 9,233 | 41,033 | 197,727 |
| | | 5,591 | 31,814 | 171,300 |
| 4·5 | 12·0 | 15·5 | 69·0 | 332·3 |
| | | 9·4 | 53·5 | 287·9 |

f these numbers to the number of stars given in
column 4 of the above table, are—

| $^{m}\cdot0$ and lighter. | Total No. in B.D. | Exp. 20s. | Exp. 3m and 6m. | Exp. 40m. |
|---|---|---|---|---|
| ·396 | 1 | 1·171 | 6·08 | 28·2 |
| | | 0·762 | 4·59 | 24 8 |
| ·360 | 1 | 1·431 | 6·76 | 31·0 |
| | | 0·869 | 5·45 | 27·9 |
| ·407 | 1 | 1·786 | 7·59 | 42·0 |
| | | 0·951 | 6·18 | 36·1 |

during the past year, the solar activity, as shown in the numbers and areas of Sun-spots, having been remarkably small. The mean daily spotted area of the Sun, expressed as usual in millionths of the visible hemisphere, had fallen from 1464 for 1893, the year of maximum, to 111 in 1899 and 75 in 1900, and a preliminary estimate for 1901 places the figure for that year as under 30. This is much below the figure for 1889, the year of minimum in the preceding cycle, which was 78, and is practically the same as that in the year of minimum in the cycle before, 1878, when the area was 24.

M. Loewy came to Greenwich in June and discussed with the Astronomer Royal the details for the redetermination of the Paris-Greenwich longitude referred to in the last Report. It was arranged that the operations should be carried out in the spring and autumn of 1902. The four observers (two French and two English) will use transit instruments of identical form, the four which were used by the British observers in the Transit of *Venus* expedition of 1874. Two of these, D and E, were sent to Paris in October, and M. Loewy reports that he finds them satisfactory. Trial observations with B and C are being made at Greenwich.

Mr. Dyson and Mr. Maunder went out on the part of the Royal Observatory to Sumatra and Mauritius to observe the eclipse of the Sun on 1901 May 18, and secured a valuable series of photographs. Preliminary accounts of their observations were read at joint meetings of the Royal and Royal Astronomical Societies on October 31, and are printed in the *Proceedings of the Royal Society*, vol. lxix., and also as an appendix to vol. lxii. of the *Monthly Notices*.

The printing of the volume of *Greenwich Observations for* 1899 is completed, and a specimen copy has been received. The volume for 1900 is printed as far as the end of the Annual Star Catalogue. The heliographic results are also printed. It is hoped that a first volume of astrographic measures, embracing the zones from declination 64° to declination 72° (about one-half of the part undertaken), may be published by the end of 1902.

The re-arrangement of the library and preparation of card catalogues has been continued, and is within a short distance of completion.

*Royal Observatory, Cape of Good Hope.*

The 24-inch object-glass of the McClean telescope, which had been sent to Sir Howard Grubb for correction in 1899 October 31 was received in 1901 February 16. After exhaustive tests it was found to be somewhat improved as to chromatic correction, and the images towards the edges of the photographic field free from coma; but the minimum focus remains still on the less refrangible side of Hγ, and not on the more refrangible side as was desired. The object-glass has been accepted.

tion of Mr. McClean's munificent gift was marked
ing of the Inscription Stone by His Excellency
(the Hon. Sir Walter Hely-Hutchinson) on
The stone bears the inscription :—

897. THE VICTORIA TELESCOPE.

THE GIFT OF FRANK MCCLEAN,
OF RUSTHALL, KENT.
DAVID GILL, H.M. ASTRONOMER.

s cut during Mr. McClean's visit to the Cape in
ere was every expectation that the instrument
eted in the year of Queen Victoria's Jubilee.)
ncy stated that it had been the desire of H.R.H.
Cornwall and York to perform that ceremony on
his recent visit, but owing to the great number of
nents which had been pressed upon His Royal
l fallen to his (the Governor's) part to do so.
ed-plate of the new transit-circle reached the
March, the piers and remainder of the instrument,
mators, in April.
y was experienced in erection and adjustment, but
time was given to experimental work in connec-
ating the piers from heat and in improving the
uminating the microscopes, &c.
ment is uncovered, for observing, by rolling back
of the steel Observatory. An admirably working
arried out for opening and closing the Observa-

each site until the cores brought up by the diamond drill showed that the unweathered rock of the Malmesbury beds, free from crack or fissure of any kind, had been reached. The corresponding depths were :—

South meridian mark, 24½ feet ; south collimator pier, 30½ feet.
North meridian mark, 16½ feet ; north collimator pier, 34 feet.

As piers of such height could not be relied upon for permanency, H.M. Astronomer devised a plan by which the optical centres of the two long focus lenses and the centres of the two meridian marks could be rapidly and accurately adjusted, at any moment, vertically over the corresponding optical centres of lenses attached to the bed-rock below. Thus all azimuths could be referred to bearings defined by points attached to the solid rock.

The Admiralty having sanctioned the necessary cost, the work of sinking the shafts has been begun. Having regard to the depth below the surface of the ground and the age, thickness, extent, and uniformity of the quartzose Malmesbury beds, the proposed system of meridian marks will probably prove to be the most stable of any yet erected. When the work has been completed and the results tested an account of the method will be communicated to the Society.

The errors of fifteen out of the sixteen microscopes belonging to the instrument have been thoroughly investigated and the corresponding corrections computed.

Some experiments still in progress with regard to illumination of the circle of microscopes have to be completed before investigation of the division errors is undertaken.

The sinking of the water-tight shafts for giving access to the underground meridian marks and the erection of the collimators, long focus lenses, and overground marks will occupy at least six months, during which time it will probably be possible to complete the investigation of the errors of division of the circle and the pivot errors.

*The annual results of meridian observations*, made under the direction of Mr. Stone, 1878–79, have been printed, thus completing the issue of results of all the work done under his direction.

The printed copies of annual results, 1896 and 1897, were by inadvertence sent to the Cape, whence their distribution by post would have been unduly costly. In obedience to Admiralty orders they were returned to Greenwich for distribution in the regular way.

The annual results, 1898 and 1899, completing the meridian observations of the astrographic catalogue-plate standard stars for the zones $-40°$ to $-52°$, have also been printed. This volume was also by inadvertence sent to the Cape, and has since been returned to Greenwich for distribution along with the companion volume 1896–7.

ogue of 8560 stars for 1900, derived from the above-
bservations, is now complete in MS., except the
the proper motions. The preparation of the cata-
olved applications of corrections in R.A. depending
e to the separate observations of each observer, and
n and application of systematic corrections to each
R.A. and declination, in the manner described in
tion to the annual volumes in question. These
ave produced a very marked improvement in the
the separate results.
Catalogue for 1900, as thus formed, has been com-
Gould's Zones, the Cordoba General Catalogue, the
ues for 1840, '50, '60, '65, '80, '85, '90, the Melbourne
or 1870 and '80, and is in course of comparison with
ew edition of Taylor's Madras Catalogue. The whole
ith the resulting proper motions, will probably be
ss before the end of the current year. The observa-
, azimuth, and miscellaneous stars observed 1896–99
duced to 1900 and will form a small supplementary

numbers for 1903 (corresponding to Finlay's star-
bles) were distributed along with last year's report;
4 are in the hands of the printer.
ltations observed between 1881–1895, both inclusive,
duced and compared with Hansen's tables. The MS.
ds of the printer and will form Part 3 of Vol. II. of
*f the Cape Observatory.*
ral work of the transit circle has been confined to

| | D.B. | R.R. | D.D. | R.D. | Total. |
|---|---|---|---|---|---|
| Phenomena predicted by N.A. Office | 2 | 1 | 19 | 13 | 35 |
| Other occultations ... ... | — | — | 60 | 2 | 62 |
| | | | | | 97 |

Of these occultations 13 stars were observed by 2 observers.

" " 3 " " " 4 "

Encke's Comet was looked for on three nights but not seen. The observations of Giacobini's Comet, secured in 1900 December, were published in the *Ast. Nach.* 3741.

Some photographs and rough "circle places" of the Great Comet of 1901 are published in the *Monthly Notices*, lxi. p. 508.

Additional observations on one night with the 18-inch, and on twenty-nine nights with the 7-inch equatorial are published (*Ast. Nach.* 3733).

The weather during 1901 has been exceptionally unfavourable. During the month of January the rainfall amounted to 5 inches, whilst the average rainfall for the same month is 0·75 inch; the greatest rainfall ever previously recorded is 2·5 inches. The general character of the definition throughout the year was much worse than usual.

With the 18-inch visual telescope $\alpha$ *Centauri* has been measured as a double star on six days by Gill and twenty-seven days by Innes.

Mr. Innes has besides made 342 complete sets of measures (distance and position angle) of 224 different pairs of double stars, and has detected 36 previously unrecorded double stars during the year, viz. :—

With the 18-inch 13 pairs, of which 8 are under 1″ distance.

" 7-inch 18 pairs.

Three previously unrecorded double stars have also been detected by Mr. Pett with the transit circle, and two by Mr. Woodgate in examining the catalogue plates.

The most interesting of the new pairs are :—

| | Distance. |
|---|---|
| $\tau_2$ *Lupi* ... ... ... ... ... | 0″·3 |
| *h* 4625, chief star ... ... ... | 0·3 |
| U.A. 13½ *Horologii* ... ... ... | 0·25 |
| $\phi$ *Argûs* ... ... ... ... ... | 20 faint comes |

Variable stars requiring observations for determination of their elements were observed by Mr. Innes throughout the year. In course of the observations several new variables have been discovered. Particulars in advance of publication have been sent to Professor Müller, at Potsdam, for incorporation in the new A.G. Catalogue of variable stars.

vestigations will form part of "A Revision of the graphic Durchmusterung" (*Cape Annals*, vol. ix.), of llowing parts are ready for press :—
ion of Kapteyn's lists. (In hands of the printer.)
ination of stars suspected of variability.
vations of proved variables.
vations of stars marked * or ? by Kapteyn in the

f *errata* in catalogues of southern stars.
f coloured stars observed in course of the revision.
will be added a list of stars having considerable ns. This list is waiting for the results of meridian not yet completed.
ing of the 24-inch object-glass was begun on and continued with varying separation of the lenses 8, when the object-glass was accepted.
ioned in last year's report to the Admiralty, the llow colour of the three prisms of the line of sight produced an undue absorption of light in the region and $H_\delta$; and Mr. McClean, with his wonted provided for a new battery of four prisms of very glass giving together rather less dispersion and the on as the three original prisms of very heavy glass.
ence of a cable message from the Cambridge Company to the effect that the new prisms by ready, the spectroscope was shipped to Cambridge —a few days before the appearance of the great e spectroscope has not yet been returned to the

resistances for regulation of the illumination were introduced. The work occupied three and a half months and was admirably done by Mr. Miller, the optical fitter attached to the Observatory, who had just returned from service at the front.

In consequence of these repairs the opposition of *Uranus* was lost, but the following oppositions of major planets were observed :—

| | No. of Observations. |
|---|---|
| Opposition of *Mars* ... ... | 48 |
| ,, *Jupiter* ... ... | 22 |
| ,, *Saturn* ... ... | 28 |

(On account of bad weather *Neptune* was not observed until early in 1902 January, but 30 observations have been secured previous to January 11.)

The triangulation of the comparison stars for *Uranus* 1897–1900 and *Saturn* 1898 has been completed by 21 observations of distance and 9 of position angle.

The triangulation of the comparison stars for *Neptune* 1897–1900 has been completed by 45 measures of distance including standards.

Forty-eight supplementary measures of distance (including standards) have been also made in connection with the triangulation of the South Polar area.

H.M. Astronomer has gratefully to acknowledge very valuable series of observations of comparison stars from the principal meridian observatories.

The Polar triangulation includes 22 stars situated within 2 degrees of the pole, and these offer 122 distances, all of which were measured from three to six times each with the heliometer. In other words, the observations afford 122 equations of condition for determination of 44 unknown coordinates. These equations have been formed and solved. The results have been forwarded to Professor Harold Jacoby as a basis for his discussion of an early Cape series of circumpolar photographs.

The details of the heliometric triangulation are in course of preparation for press.

An extension of the circumpolar triangulation has been planned extending to stars 6° from the pole, and 137 observations of distance (including standards) have been made in connection with that work.

Forty-eight heliometer observations of *α Centauri* as a double star have been made.

Mr. Bryan Cookson between June 24 and September 27 made heliometer measures on thirty-eight nights of the mutual distances and position angles of *Jupiter's* satellites on the same plan as that of Gill's observations in 1891. From 28 to 30 complete observations both in distance and position angle have been secured for each pair of satellites. A pair of standard

bserved at the beginning and end of each night's

servations have all been completely reduced. An ased on Souillart's theory was computed, and the f the tabular distances and position angles for the servations is just completed. The coefficients of rrections to the constants of the theory are now ted, and the complete equations of condition will soon solution.

astrographic telescope the following work has been :—

| | No. of Plates. | No. of Exposures. | Duration of each Exposure. m m m |
|---|---|---|---|
| re chart plates passed ... | 57 | 171 | 30, 30, 30 |
| „ rejected... | 23 | 69 | 30, 30, 30 |
| logue plates passed ... | 200 | 600 | 6, 3, 20 |
| ... ... ... ... | 17 | ... | various |
| ... ... ... ... | 5 | ... | „ |

on to these, forty-six plates of long exposure ($30^m$ search for an ultra-Neptunian planet, have been ordance with a request from Herr Hans E. Lau, gen. The examination of the plates is not yet

equest of Dr. Backlund contact glass positives of tes have been sent to Pulkowa.

he year 159 catalogue plates, containing 100,203 been measured in both coordinates in each of two

some oxen; he fell ill of typhoid fever, and the survey party was deprived of his services for the season. It was not until the end of April that transport could be organised and a start be made from Baruka. The original plan was that the reconnaissance and beaconing parties should start some weeks in advance of the observing party, but this was impossible because of delay in transport equipment; and, owing to Mr. Heatlie's illness, both the reconnaissance and beaconing fell entirely on Mr. Antrobus. Heavy clearing work had to be done in many places, and progress in reconnaissance and beaconing could not be made to keep pace with the observing. At the more northern stations first the waggons and then carts had to be abandoned and all transport be done by native carriers. As the result of these delays, two, perhaps three, of the stations south of the Zambesi will require yet to be occupied with the geodetic theodolite. In the interval between the work of the two last seasons the wires used in measuring the base near Salisbury were recompared at the Royal Observatory, the measurement of the angles from the base to the main triangulation was completed, and signals were exchanged for longitude of Salisbury, Mr. Simms's personal equation being determined at the Cape before and after the longitude observations.

The operations northwards from the Zambesi will involve an entirely new departure. Observers and supplies will have to be landed at Chinde and be brought up the Zambesi beyond Zumbo, where transport by native carriers would be organised.

The operations of the Anglo-German boundary survey are in steady progress.

The field work of the triangulation has practically been completed, and Major Laffan with Lieutenant Doering are engaged in beaconing the boundary from Reitfontein southwards to the Orange River. Meanwhile the computations of the northern part of the work are being completed, and advantage will be taken of the first favourable opportunity to beacon the remainder of the boundary, which in many places is so arid that it cannot be traversed except in seasons when there is an exceptionally abundant supply of wild melons, as no natural water supply, other than the juice of these melons, exists.

The printing of the re-reduction of Bailey's survey has been at last completed, and the volume is ready for distribution.

The meteorological observations made during 1900 have been communicated to the Cape Meteorological Commission.

Since November 1 an hourly signal has been supplied to the General Post Office at Cape Town, whence by a relay the signal is transmitted along a special line by which the station clocks on the Wynberg line are automatically regulated. The ordinary time signals throughout the colony and the regulation of chronometers for His Majesty's ships have been continued as usual.

tcher, formerly assistant to Mr. Newall at Cam-
l the Observatory staff on December 17.
gh, chief assistant, has been absent on leave in
e September 11.
an Cookson, having completed a post-graduate
dy at Cambridge, came to the observatory in 1901
er to study practical astronomy.

*Royal Observatory, Edinburgh.*

ge has been made in the arrangements for carrying
service for the cities of Edinburgh and Dundee,
e being supplied as in former years from the Moly-
ime clock of this Observatory. During four days in
ne-gun was not fired, the gun being then under
two other days in the year there was also no gun
to temporary derangement of the mechanism. On
ovember the time-ball was not raised on account of
of the wind. With these exceptions, the time service
atisfactorily.
e has been devoted to observation of the new star
n the constellation *Perseus* by Dr. T. D. Anderson,
on February 21, at $14^h\ 40^m$ Greenwich mean time.
the time of discovery, was of the 2·7 magnitude, and
bluish white light. At $6^h\ 58^m$ G.M.T. Dr. Cope-
d the *Nova* as 0·3 magnitude brighter than *a Tauri*,
$5^m$ considered it equal to *Procyon*, which it closely

any changes which the law of rotation may undergo during a cycle of solar activity. Dr. Halm has read two papers before the Royal Society of Edinburgh on subjects connected with his theoretical solar investigations, and has contributed three other papers to the *Astronomische Nachrichten.*

The reduction of the meridian observations made between 1834 and 1845 has been continued by Dr. Halm, assisted by the temporary computer, Mr. Henderson. The Catalogue for 1840 is now finally compiled, and the computations of the new values for the precessions nearly completed. Some time will still be required for the comparison of the star places with other catalogues. The new places for those stars which are contained in the *Fundamental Catalog der Astronomischen Gesellschaft* have been forwarded to Professor Auwers, of Berlin.

Throughout the year the Troughton and Simms' meridian circle has been under the charge of Mr. Clark. Observations of Sir David Gill's zodiacal stars have been continued as far as practicable, though the requirements of other pressing duties have interfered to some extent with the work, and the number of observations made is consequently much less than usual. The instrumental errors have been determined at frequent intervals, and have been found to be quite as satisfactory as in previous years. Every opportunity has also been taken of determining the corrections to the standard clock used for the time service of the Observatory and the city. In addition to the ordinary "outside air" and "attached" thermometers, an "aspiration" thermometer by Fuess has been used in all the meridian observations made during the year. This instrument has been suspended alternately at the north end and at the south end of the Transit House, and has been read as a wet and dry bulb in conjunction with the ordinary thermometers. It is confidently expected that in the reduction of the observations for refraction greater accuracy will thereby be obtained.

The Milne seismograph, erected 1900 December, has been in continuous operation throughout the year with most satisfactory results. The records up to December 31 have been forwarded to Professor Milne, Secretary to the Seismological Committee of the British Association. Within the year seismograms of fifty-six undoubted earthquakes were found on the photographic rolls. Of these, all except one had semi-amplitudes measured on the paper varying from a quarter of a millimètre to 5·5 mm. Assuming the motion of the boom to correspond to the actual tilt of the supporting pillar, these semi-amplitudes would be equivalent to tilts of the pillar out of the vertical through angles varying from 0·18 to 3·98 seconds of arc. The exception occurred on August 9, when a semi-amplitude of 8·5 mm. was shown on the photographic roll, equivalent, on the above assumption, to a tilt of 6·08 seconds out of the vertical. This was one of a series of four earthquakes, all of considerable amplitude, recorded between $9^h\ 36^m$ A.M. of August 9, and $1^h\ 6^m$ P.M. of the 10th,

period the instrument was in a state of disturbance
ve hours. Observation of the bifilar pendulums was
in July, it being considered unnecessary to keep
g any longer, since the installation of the Milne
had proved so satisfactory. It has been thought
wever, to start one bifilar pendulum afresh to be
onjunction with the Milne seismograph.

prological observations have been carried on by the
Observatory as in former years, and a monthly copy
adings has been supplied to the secretary of the
eorological Society for the use of the Registrar-
Scotland, the monthly means being published in the
uarterly Returns. A copy of the temperature and
ngs for each week has also been furnished to the
neral at his request. The Robinson anemometer
barograph have also been kept in operation without
and the weekly readings of the rock thermometers
ill have been continued. A paper on the observa-
thermometers was read before the Royal Society of
February by Mr. Heath, and has been published in
e *Transactions* of the Society. The paper contains
readings of the thermometers from May 1888 to
99, with their monthly, quarterly, and annual
*résumé* of the whole series of observations since the
e first set of thermometers in 1837, and a deduction
curves therefrom. The reduction of the Robinson
urves from the date of the erection of the instru-
kford Hill has been completed by Mr. Clark.

Daylight observations of *Nova Persei* and comparison stars were obtained on February 25, 28, March 1, 2, 3, 5, 7, 12, 21. On March 25 *Nova* was not visible at 3 P.M. in a perfectly clear sky; cloudy days followed till April 1, when *Nova* was again visible on the meridian, the magnitude being estimated at $4\frac{1}{2}$. The resulting places were communicated to the Society in April (*Monthly Notices*, vol. lxi. p. 396).

Early in July three very faint circumpolar stars, together with a number of comparison stars, were observed for Dr. Stechert, of Hamburg. The resulting places, reduced to mean equinox at the beginning of the year, were communicated to him on August 31.

For instrumental deviation there have been made 78 observations of *Polaris* at the upper transit and 91 at the lower, and 61 observations of other close circumpolar stars. The observations of *Polaris* have also been utilised in making a fresh determination of the intervals of the wires.

The nadir point, level, and line of collimation have been regularly observed, and the constants for instrumental correction have been obtained from 312 equations.

At the request of Dr. Auwers a preliminary list of Cambridge transit observations made during the years 1847–1869 was communicated to him early in the year; corrections to the clock-star places used in the reductions have been sent from Berlin, but owing to the pressure of other work the preparation of the catalogue reduced to epoch 1855·0 is not yet in progress.

*Sheepshanks Photographic Equatorial.*—At the date of the last Report the work on *Eros*, which had been in progress since 1900 October 1, was nearly concluded. Extremely bad weather had prevailed throughout January, and it was decided to make an end of the series at the end of the month. In all, 596 exposures had been made on the planet, of which about 350 are fit for measurement. In the four months' work, despite the bad weather, enough material had been collected to occupy for a long time the energies available for measurement and reduction; to abstain for a while from making more photographs was therefore advisable. A temporary resumption of observation was necessitated by the appearance of *Nova Persei*, of which a number of plates for position and of series for photographic magnitude were secured. But the star soon passed beyond the hour-angles at which the telescope could reach it, and thenceforth to the end of the year observing was entirely suspended.

Much time was spent in developing a method of reduction of the *Eros* photographs by comparison with the tabular positions computed from two entirely separate heliocentric ephemerides of the Earth and of *Eros* expressed in rectangular coordinates. For the purposes of the experiment fifty exposures on two nights were measured and compared with special ephemerides very kindly computed for the purpose by Professor Millosevich. An account of the method, with the results of the preliminary

reductions, was communicated to the Society in November. Briefly it may be said that the results which the new telescope and measuring machine give are of a high order of accuracy, and that the method used seems to be so far promising as to deserve a more extended trial, which will be made.

When the *Eros* measures and reductions had got well under way it was time to resume observational work. The plane mirror has been re-silvered, the whole of the adjustments revised, and the instrument is now ready (18 Jan.) to begin work on a list of objects which may, it is hoped, have a sensible annual parallax. Only the very best nights will be given to this work; at present not much time can be spared from the solar parallax reductions.

*Meteorological Observations.*—The meteorological work has been continued on the same lines since 1899 July, when a change was made in the hours of recording barometer readings and temperatures. Weekly and monthly reports are communicated to the Meteorological Office. These include the records of hours of bright sunshine and of the rainfall.

### *The Newall Telescope, Cambridge Observatory.*

The Newall telescope was used for observations on 91 nights in the course of the year 1901.

Throughout the year the instrument has been used in connection with the spectroscope. For the first two and a half months the four-prism spectroscope was employed in completing the material for the study of highly dispersed spectra of the brightest stars; it was also used in securing photographs of *Nova Persei*. Thirty photographs of the spectrum of the *Nova* were obtained between February 25 and March 10. The spectrum of *Capella* was photographed at certain epochs in its period, for which information is still needed for the better determination of the orbit. The spectrum of *α Persei* has been closely studied in continuation of observations communicated to the Society last year. The later observations (*Monthly Notices*, lxii. 124) show that neither of the periods suggested in the first communication will represent all the observations. The cause of the observed variation in velocity is not yet clear, and, in fact, the existence of it finds no support in the observations made at Potsdam and Mount Hamilton.

On March 11 the four-prism spectroscope was dismounted and taken to Sumatra for observations of the total eclipse of the Sun on May 17–18. A preliminary report on the observations made in Sumatra has been communicated to a joint meeting of the Royal Society and the Royal Astronomical Society (*Proc. Roy. Soc.*, vol. lxix. p. 209).

Arrangements had been made to fit a two-prism spectroscope to the equatorial, in place of the four-prism. The cast-iron box

for holding the prisms was fitted, and the instrument was adjusted in the latter part of March by Mr. A. W. Goatcher, and was steadily used throughout the rest of the year in the study of spectra of special faint stars—the *Nova Persei* included, up to November 2—and of planetary nebulæ.

A new annex has been added on the north side of the dome during the summer. It will be used as a laboratory for experimental work, which has been hitherto carried on under considerable difficulties arising from lack of space. The increased room thus obtained will, it is hoped, also give opportunities for students to take part in the work of the Observatory.

Mr. A. W. Goatcher, after nine years' work at the Observatory, was appointed to a post as computer at the Royal Observatory, Cape of Good Hope, and left Cambridge on November 23 for South Africa. Mr. H. J. Bellamy has been appointed assistant in his place.

### *Dunsink Observatory.*

The meridian circle has been used throughout the year in the observation of the stars contained in Sir David Gill's list of 2798 zodiacal stars. The total number of these observations made since the last report is 7936. Of these 3550 observations were made of the right ascensions of the zodiacal stars and the same number of the declinations; 291 stars of the *Berliner Jahrbuch* were observed for determining the error of the Dent sidereal clock, and 268 declinations were taken for the equator point of the meridian circle; 69 determinations were made of the level error, 64 of the collimation, 62 stars of the *Berliner Jahrbuch* were observed for the error in azimuth, the nadir was determined on 64 occasions, and the error of runs on 18. The observations have been reduced to apparent place to 1901 January 31.

Photographic observations with the Roberts equatorial have been continued on the lines of former years. The South equatorial has only been used for occasional observations and by visitors on the monthly open nights.

The time service to Dublin has been continued as heretofore.

### *Durham Observatory.*

The equipment has been completed and improved in many respects during the last year. A new sidereal clock by Kullberg has been going in a very nearly perfect manner. It is placed in the old observatory upon the stone pillar which, as in other old-fashioned places, runs through the building to support the equatorial. It is found that without special contrivance the range of temperature here is very small. In the month of

py of Professor G. W. Hough's printing chrono-
by an American firm, was delivered. Professor
e kindest manner, tested and altered the work until
swer for its accuracy. This instrument, which
ably, abolishes the labour of reading and tran-
ordinary drum record, as it prints the observations
a paper tape. The accuracy of its records can be
ten as may be thought necessary. It is used in
with the Almucantar. A movable eyepiece and a
oth detached from the floating parts, have been
e Almucantar, and in October, owing to some
its observations, the float and telescope were raised
ugh and some projecting studs removed from the
e trough, as it was suspected that there was not
nt clearance between these and the float. When the
replaced the anomalies disappeared, and since then
ns have fully come up to expectations : the instru-
en in use on all good nights in November and
Mr. Chandler's arrangement of the reductions has
at recast, and this has made it necessary to make a
tion book to facilitate reductions.
e year Professor E. C. Pickering has kindly sent
MSS. of the photometric observation of *Jupiter's*
le at Harvard College Observatory. The number
1878 to 1900 is 676, and the light curves of these
arted, and are now ready for discussion. This work
uch easier byfacilities which Dr. Downing kindly
Ir. Carpenter for copying arguments and other

taken on 110 nights, and the meteorological work has been carried on as in former years.

### *The Liverpool Observatory, Bidston.*

No alteration or increase has been made in the instruments in use at this Observatory during the past year, and the purposes for which the Observatory was founded have been steadily and systematically pursued. These objects embrace the distribution of time signals, the examination of chronometers, and other philosophical apparatus, enquiries into the climate of the locality and the prosecution of such astronomical observations as the optical means permit. To take these in order it may be said there has been no failure of the time gun during the year, and the accuracy with which it has been fired is quite satisfactory. The number of chronometers, sextants, &c., deposited for test during the year is rather greater than usual; but considering the apparatus provided by the Board for this purpose, the general result is distinctly disappointing. The Richard thermograph, mentioned in the last report, and which is mounted in a Stevenson screen on the southern side of the building, has confirmed the Director's suspicions that the record of temperature in the past has generally been too high. The thermometric readings now made on the northern side seem trustworthy.

The observation of stars near the Pole, recommended by Professor Auwers, has been discontinued. Small but rapid changes in the azimuthal error, over which no sufficient control could be maintained, injured the results and would probably render them useless. The level error is not subject to the same kind of fluctuation. The equatorial has been used for comet observations, and also for double stars. Slight repairs are made to this instrument from time to time, and it is kept in a state of efficiency.

The earthquake observations, mentioned in the last report, have been continued throughout the year with a Milne seismograph for the regulation of unfelt tremors. This Observatory took part in connection with some others in an enquiry as to the effect of geological structure in influencing the record. The results have been communicated to Professor J. Milne, F.R.S., who has reported on them to the Earthquake Committee of the British Association. The attempts at observation with the bifilar pendulum have been definitely abandoned. There appeared to be no connection between the observed displacements of the two instruments, and it seemed not unlikely that an accumulation of rust on the iron rods sunk beneath the surface of the cellar, and which supported the pendulums, obscured the record and introduced irregular motions.

*Radcliffe Observatory, Oxford.*

e year the work of bringing up the arrears of reduc-
to in last year's report, has been pushed on steadily.
ject in view systematic observation with the transit
n discontinued during the greater part of the year,
y of the staff largely directed to this work, which is
e satisfactory condition.
rations of right ascension have been reduced to mean
beginning of the year of observation as far as the
nd the reductions of the observations taken in 1899
in a forward condition.
n distances have been completely reduced to mean
as 1899 February 22. The reduction of zenith
erved from that date till the end of 1901 is well in

e year the printing of the forty-eighth volume of
Observations has been completed, and copies have
ted as usual. This volume contains the meteoro-
obtained at this Observatory from 1892 to 1899
the next volume, which, it is hoped, may be in the
ds before the date of the next report, will be
he astronomical results obtained since 1892.
r progress has been possible in the reduction of the
and transit observations made between 1774 and
irector's application for a grant for this purpose
again postponed by the Government Grant Com-

its discovery, with a wedge photometer kindly lent by Sir Howard Grubb, and a few spectroscopic observations were made.

A special watch for *Leonids* was kept at this observatory on the night of November 14–15, the results of which have been already communicated to the Society.

Meteorological observations and automatic registrations have been maintained as usual throughout the year. Observations of underground temperature by means of platinum-resistance thermometers have been carried on uninterruptedly. The mercury-contact switch-board, for making connection between the resistance box and the several thermometers, was replaced on May 23 by one with copper contacts, which now seems to work very satisfactorily.

The mechanical parts of the large refracting telescope which, for the last three years, Sir Howard Grubb has been building for this Observatory are now complete, and the instrument is at present being dismantled, and the various parts are being packed for transport to Oxford. As reported last year, the 18-inch visual object-glass is finished, and the 24-inch photographic object-glass will probably be ready by the time the mechanical parts are erected. At Oxford progress has been made in the construction of the rising floor, the galleries, and the internal fittings of the dome. The framework on which the floor rests has been completed and hung on its counterpoises, and the work has been carried as far as it seems advisable to go before the heavier parts of the instrument have been mounted in position. The work of erecting the telescope at Oxford will be commenced forthwith.

During the year a very large expense has been incurred for repairs to the central tower, 100 feet in height, which constitutes such a striking feature of the Observatory building. The walls and ornamental projections of this tower, which was finished in 1795, had, like so many of the Oxford buildings, suffered severely from the weather, and had become in some places dangerous through the falling of pieces of stone. The greater part of the tower has been very thoroughly restored and the work is still in progress.

*University Observatory, Oxford.*

The main work of the year has been the measurement and reduction of plates for the Astrographic Catalogue, and two more zones have been completed, viz. zones $+28°$ and $+29°$, so that five out of the seven are now finished. The number of plates completed during the year 1901 is 151, bringing the total number up to 900 out of 1,180. It is hoped that the whole work may be finished within two more years.

In the early months of the year thirty further plates were taken of *Eros* and surrounding stars, and a large number of measures made. Acknowledgment should be made of the generous help of Mr. Frank Robbins, F.R.A.S., who has computed by

rom the ephemeris of M. Millosevich 367 places of
mes corresponding to the exposures—a considerable
rtaking.

ns of the region surrounding *Nova Persei* were
uary 25 and following days, and a resulting survey
was communicated to the Society by Mr. Bellamy
*ces*, vol. lxi. p. 340 ; see also p. 473). A similar
region round the variable *RU Herculis* was made
by him (*Monthly Notices*, lxii. p. 73).

Plummer, who was appointed second assistant at
ry last August, carried out an investigation of the
ors of measurements on photographic plates sug-
per recently published by M. Loewy ; and found
od of making measures in two positions of the
by 180° in position angle (which originated, it
this Observatory) has an important and rather
ect in the diminution of systematic error (*Monthly*
i. p. 618).

son of Dr. Küstner's meridian observations with
otographic measures was made, and his (practically
gnitude equation deduced, the results satisfactorily
s own results obtained by the "screen" method
*ces*, vol. lxii. p. 3).

past year the Director carried out and published
n of the formulæ and tables convenient for com-
rlapping plates (*Monthly Notices*, vol. lxi. p. 422). He
a note on the rotation of a siderostat field (*Monthly*
i. p. 122) and another on a suggested method of

Seabroke have continued measuring double stars, and the measures of the last five years have been prepared for publication by the Society.

*Stonyhurst College Observatory.*

The solar surface has been observed on 235 days, and the results are recorded by 144 drawings of spots and faculæ and 91 blank sheets. The mean spotted disc area deduced from these is 0·29,* against 0·55 of last year; and the mean daily range of the magnetic declination is 9′·1, against 9′·7 of the preceding year.

The experiments with a small prismatic camera mentioned in last year's report were complete just before the appearance of the new star in *Perseus*. A detailed description of the instrument is given in the January number of the *Monthly Notices*, in the introduction to a paper on the spectrum of *Nova Persei*, 1901. Eighty-six photographs of this spectrum have been obtained: half of these were taken between February 28 and April 26, and the other half between August 24 and December 20. Several attempts were made in May, which failed through the loss of light at the low altitude of the star.

In the intervening summer months the camera was employed on *Arcturus* and *α Cygni* for the construction of its wave-length curve, and on *β Lyræ* and *γ Cassiopeiæ* for the extension of their spectra into the shorter wave lengths.

The visual spectrum of the *Nova* was observed on 15 nights in March and April.

*Markree Observatory.* (*Col. E. H. Cooper's.*)

During the year this Observatory has been under the charge of Mr. F. W. Henkel, B.A., as previously, and of Mr. J. R. Armstrong in his absence.

The regular meteorological observations of a station of the second order have been continuously carried on and reduced as usual, weekly and monthly returns of barometer, temperature, sunshine, rainfall, wind and cloud, &c., having been sent to the Meteorological Office at London, weekly reports to the Registrar-General at Dublin, summaries of rainfall to Dr. Mill and Mr. Wallis at Camden Square, and to the local newspapers. Some magnetic observations have also been made. Determinations of local time with the transit circle with the instrumental corrections, &c., have been regularly made, also some observations for confirmation of the longitude of this Observatory by the method of "lunar culminations."

A few lectures were delivered in the month of February.

* The unit being $\frac{1}{1000}$ of the visible disc.

nid meteors were scarcely seen here, though the finer than is usually the case in November. The total 901 was 44·85 inches, or 3½ inches above the average.

*Crossley's Observatory, Bermerside, Halifax.*

s been no change in the routine work of this Observa- e last report. The observations of *Jupiter* and *Mars* the year 1901 and the measures of double stars 890 have already appeared in the *Monthly Notices.*

*singham Observatory.* (*Rev. T. E. Espin's.*)

he year the measurement of double stars between 60° has been continued. The total number of nights ervations have been secured is seventy-six, the number 2289, and the number of stars 349 : of these seventy- and the mean measures of the new stars have been the *Astronomische Nachrichten.*

*lliam Huggins's Observatory, Upper Tulse Hill.*

ography of the spectra of stars and of nebulæ which progress for some years has been continued during r.

being mostly circumpolar, the light variations are continuously recorded.

Transits are taken as often as required for rating the sidereal clock, which has now been in use for fourteen years, with a continually increasing accuracy as a timekeeper.

Considerable attention was given to the planet *Mars*, and between February 5 and March 21 eleven drawings were made, mostly with a power of 310. Many of the well-known features of the planet, as figured by Green and Knobel in the *Memoirs* of the R.A.S., were very well seen.

*Dr. Isaac Roberts's Observatory, Crowborough Hill, Sussex.*

The photography of nebulæ and star clusters has been carried on during the past year on the same plan as in preceding ones. Sir W. Herschel's list of fifty-two suspected nebulous regions, which Dr. Dreyer called attention to as deserving of photographic scrutiny, have now been observed in detail, and the results will be communicated in a special paper. A list of objects photographed in the course of the year is herewith appended on the same model as those in preceding reports.

*List of the principal Photographs taken in* 1901.

| | R.A. h m | Decl. ° ′ | Expos. h m |
|---|---|---|---|
| Neb. H II. 853 Andromedæ ... ... | 0 5 | +32 48 | 1 30 |
| Neb. *h* 12 Piscium ... ... ... | 0 10 | +11 53 | 1 30 |
| Neb. M. 31 Andromedæ ... ... | 0 37 | +40 43 | 1 30 (three) |
| Neb. H V. 20 Ceti ... ... ... | 0 42 | −21 18 | 1 30 |
| Neb. H V. 19 Andromedæ ... ... | 2 16 | +41 54 | 1 30 |
| Region of *Nova* Persei * ... ... | 3 24 | +43 34 | 1 30 (Sept. 15)<br>2 0 (Oct. 9) |
| H's Nebulous Region No. 13 ... | 4 2 | +25 11 | 1 30 |
| Hind's variable nebula in Taurus ... | 4 16 | +19 17 | 1 35 |
| Cl. of the *Hyades* in Taurus ... ... | 4 24 | +15 26 | 1 0 |
| H's Nebulous Region Nos. 14 and 15 | 4 24 | +35 8 | 1 30 |
| „ „ „ No. 16 ... | 4 26 | − 7 30 | 1 30 |
| „ „ „ „ 17 ... | 4 29 | +20 50 | 1 30 |
| Cl. H VIII. 8 Tauri ... ... ... | 4 40 | +18 53 | 1 0 |
| H's Nebulous Region No. 18 ... | 4 44 | +20 50 | 1 30 |
| „ „ „ Nos. 20 and 21 | 5 17 | +25 1 | 1 30 |
| „ „ „ No. 22 ... | 5 29 | − 6 56 | 1 30 |
| „ „ „ „ 23 ... | 5 30 | − 2 43 | 1 30 |

* Five minutes' exposures of the *Nova* were taken on March 3, 5, 6, 12, 24, 25, and April 4. On 1902 January 5 and 12 exposures were also obtained of $2^h\ 54^m$ and $90^m$ respectively.

| | R.A. h m | Decl. ° ′ | Exp h |
|---|---|---|---|
| itudes near $\epsilon$ Orionis ... | 5 35 | − 1 16 | 0 |
| lous Region No. 26 ... ... | 5 37 | − 6 57 | 1 |
| ,, ,, 27 ... ... | 5 43 | + 1 8 | 1 |
| ,, ,, 30 ... ... | 6 40 | +41 16 | 1 |
| ,, ,, 32 ... ... | 9 36 | +71 13 | 1 |
| 265 Ursæ Majoris ... ... | 10 12 | +58 42 | 1 |
| lous Region No. 33 ... ... | 10 12 | − 9 3 | 1 |
| ,, ,, 34 ... ... | 10 22 | +51 32 | 1 |
| ,, ,, 35 ... ... | 10 41 | +62 45 | 1 |
| ,, ,, 36 ... ... | 11 4 | +62 44 | 1 |
| 224 Ursæ Majoris ... ... | 11 13 | +58 18 | 1 |
| 201 and II. 738 Ursæ Majoris | 11 42 | +48 42 | 1 |
| 202 Ursæ Majoris ... ... | 11 48 | +48 24 | 1 |
| 207 Ursæ Majoris ... ... | 12 1 | +48 2 | 1 |
| lous Region No. 37 ... ... | 12 2 | +30 37 | 1 |
| ,, ,, 38 ... ... | 12 12 | +30 37 | 1 |
| itudes near $\eta$ Virginis ... | 12 19 | − 0 7 | 1<br>1 |
| 160 Virginis ... ... ... | 12 30 | − 3 14 | 1 |
| Region in Coma Ber. ... | 12 54 | +28 29 | 1 |
| lous Region No. 39 ... ... | 13 12 | +34 8 | 1 |
| V. 63 Ursæ Majoris ... ... | 13 26 | +58 56 | 2 |

| | R.A. h m | Decl. ° ′ | Expos. h m |
|---|---|---|---|
| Index Cat. 1312 Sagittæ ... ... | 20 12 | +17 43 | 1 30 |
| Index Cat. 1318 Cygni ... ... ... | 20 19 | +39 57 | 1 30 (two) |
| N.G.C. 6914 Cygni ... ... ... | 20 21 | +42 9 | 1 30 |
| Index Cat. 1329 Delphini ... ... | 20 39 | +15 14 | 1 30 |
| Index Cat. 1344 Aquarii ... ... | 20 56 | −13 46 | 1 30 |
| Index Cat. 1360 Equulei ... ... | 21 6 | + 4 39 | 1 30 |
| N.G.C. 7040 Equulei ... ... ... | 21 8 | + 8 27 | 1 30 |
| Index Cat. 1369 Cygni ... ... ... | 21 9 | +47 21 | 1 30 |
| Index. Cat. 1378 Cephei ... ... | 21 20 | +55 0 | 1 30 |
| Index Cat. 1392 Cygni ... ... ... | 21 31 | +34 57 | 1 30 |
| Index Cat. 1396 Cephei... ... ... | 21 36 | +57 0 | 1 30<br>2 0 |
| Neb. H III. 452 Aquarii ... ... | 21 49 | + 2 28 | 1 30 |
| Neb. H III. 692 Aquarii ... ... | 21 55 | −13 41 | 1 30 |
| Neb. H II. 207 Pegasi ... ... ... | 22 3 | +30 52 | 1 30<br>2 0<br>2 50 |
| N.G.C. 7226 Cephei ... ... ... | 22 7 | +54 55 | 1 30 |
| Index Cat. 1434 Cephei ... ... | 22 7 | +52 20 | 1 0 |
| N.G.C. 7293 Aquarii ... ... ... | 22 24 | −21 21 | 1 30<br>2 12 |
| Index Cat. 1453 Aquarii ... ... | 22 41 | −13 58 | 1 30 |
| Neb. H II. 212 Pegasi ... ... | 22 55 | +29 10 | 1 30 |
| Neb. H II. 251 Pegasi ... ... ... | 22 55 | +15 27 | 1 30 |
| Neb. H II. 203 Pegasi ... ... ... | 23 4 | +17 48 | 1 30 |
| Neb. H II. 706 Cassiopeiæ ... ... | 23 9 | +60 58 | 1 30 |
| Neb. H II. 600 Andromedæ ... ... | 23 17 | +40 42 | 1 30<br>2 0 |
| Neb. H II. 226 Pegasi ... ... ... | 23 23 | +21 52 | 1 30 |
| Neb. H II. 208 Pegasi ... ... ... | 23 39 | +25 31 | 0 47<br>1 30 |
| Neb. h 2266 Cassiopeiæ ... ... | 23 40 | +69 12 | 1 30 |
| Neb. H II. 231 Pegasi ... ... ... | 23 46 | +19 33 | 1 30 |
| Neb. H II. 227 Pegasi ... ... ... | 23 59 | +20 12 | 1 17 |
| Neb. h 2302 Cassiopeiæ ... ... | 23 59 | +67 7 | 1 30 |

*Mr. Saunder's Observatory, Crowthorne, Berks.*

The principal work done at the telescope has been the completion of the micrometric measures of selenographic positions required for the reduction of photographic plates. In all nineteen points have been measured, each on not less than four nights,

them under evening as well as under morning

t of the use made of these measures has already cated to the Society, and appears on p. 41 of the mber of the *Monthly Notices*. Subsequent work plate, for which Mr. Saunder is indebted to the he Director of the Paris Observatory, has shown he 53 positions there given are sufficient for an mination of the constants, and confirms his opinion minary difficulties of the investigation have been

noonless nights the telescope has been used for g.

*Daramona Observatory.*

y part of the year the weather was as bad as the vious one, and no work could be done.

here was nearly a week of fine weather, and at f Professor G. Forbes a photographic search was r his hypothetical ultra-Neptunian planet. As the -inch reflector is so small a 6-inch portrait lens by s used. This fine lens was kindly lent for the r David Salomons, Bart. A camera for it was e tube of the 24-inch reflector, and the star- ound to be very small and sharp, except near the $8\frac{1}{2}$ inch by $6\frac{1}{2}$ inch plates which were used. The was about 5° in diameter. One photograph was

and 1901 ; 7333 transits were observed in those two years, and it is estimated that the catalogue of R.A.'s of over 2000 southern stars will be ready for press early in 1904. About 400 micrometrical measurements of double stars, mostly southern pairs, were obtained. At Professor Pickering's request the sequences observed by Sir John Herschel at the Cape have been reduced again with photometric magnitudes from the Harvard College Observatory. An increase (above that obtained with the aid of the Uranometria Argentina) in the accuracy of the catalogue of magnitudes of stars over sixty years ago has been the result of the recalculation, and Professor Pickering intends to use Herschel's magnitudes, which are frequently as accurate as those resulting from the best modern work, in a revision of the Harvard Photometry. The recalculation of the orbits of double stars has been continued, and a new orbit of *η Cassiopeiæ* has been published in the *Astronomische Nachrichten*. *Nova Persei* was regularly observed last spring.

### *Kodaikanal Observatory.*

During the past year the work on the buildings has made considerable progress and the main buildings have been nearly completed. Regular observations on the Sun were begun early in the year. On every day on which the Sun is visible it is examined for spots and faculæ, and the positions of any found are determined approximately by projection. Drawings are made of all important groups, and photographs are taken whenever it seems of importance.

Spectroscopic work could not be begun fully till some time later, but since September the large spectrograph has been in full working order, and a number of spectrograms has been obtained. Under instructions recently received from the Observatories Committee of the Royal Society, eye observations of the spectra of sun-spots, prominences, and the chromosphere take the first place in the work of the Observatory. Hence the early hours of the forenoon, which are the best for work on the Sun, are mainly devoted to eye observations.

Several photographs were taken of the great comet, but the conditions were unfavourable and the results not very satisfactory. Preparations were made for fully observing the annular eclipse in November, but unfortunately the day was one of the worst in the whole year, and only a few brief glimpses of the Sun were obtained through thick drifting fog.

Complete meteorological observations have been taken throughout the year, and actinometrical observations have been taken on suitable days with a Balfour Stewart actinometer and with Buchanan's solar calorimeter. Records have also been obtained without any serious break with a Milne seismograph.

Though the year here, as elsewhere throughout India, has

bnormal one from the meteorological standpoint, oo hours of bright sunshine. There were, however, days on which there was less than half an hour, and s on which there was less than two hours of bright me progress has been made with the erection of an building for a magnetical observatory as one of the for the magnetical survey of India. Plans and have been sent home for a spectroheliograph and ating spectroscope.

### *Melbourne Observatory.*

*ian Observations made with the 8-inch Transit Circle.*

| | R.A. | N.P.D. |
|---|---|---|
| imuth stars | 324 | 130 |
| ock ,, | 656 | ... |
| st ,, | 1151 | 1157 |

ars were selected from the Melbourne plates of the *phic Catalogue* to be used as standard reference eduction of these plates.

ate results and annual catalogue for the year 1900 epared. The reductions of meridian observations 1 are nearly up to date. The precessions for the r of stars, 3100, included in the third Melbourne ogue now in course of preparation, have been inde- omputed. The total number of standard stars for

Contact prints on glass were made of the complete series of chart plates with single exposure.

The time service, weather service, terrestrial magnetism, registration of tides, rating of chronometers for the shipping, testing of meteorological and surveying instruments, and a multitude of other duties for public local requirements were carried on as usual. The reduction of arrears of magnetic records and measurement of cloud photographs have been continued by the temporary staff of computers, and are well advanced.

The Great Telescope, 8-inch equatorial, and photo-heliograph have been used only for few occasional observations and for visitors.

This comparatively narrow limit of astronomical activity at this Observatory is the unavoidable consequence of conditions which have been explained on previous occasions, and which still exist—viz. the demands made on our time by public local requirements, the clearing up of arrear records, and the grievous circumstance that no appointment has yet been made to fill the position of Chief Assistant, which has been vacant since 1895. Moreover, protracted illness of several members of the staff has very greatly interfered with the work of the year.

### *Sydney Observatory.*

The staff of Sydney Observatory has not been changed during the year, and the work of observing the reference stars for the astrographic plates is progressing steadily. During the year the following observations have been made by Messrs. Lenehan and Raymond :—

| | R.A. | | N.P.D. | |
|---|---|---|---|---|
| Clock stars ... ... ... | 531 | ... ... | 391 | stars |
| Azimuth stars ... ... ... | 171 | ... ... | 171 | „ |
| Reference stars for plates ... | 1801 | ... ... | 1803 | „ |
| | 2503 | | 2365 | „ |

*State of Computations :—*

For 1900 star constants and corrections almost completed.

„ 1901 star constants and corrections are now being checked.

„ 1901 stars observed are now being computed.

The above and previous years make 2639 stars ready as Reference stars for the astrographic photographs.

*Photographic Branch.*—Work has been carried on steadily. There has been little rain, but the prevailing dust and smoke

has materially hindered the work. Red Hill ke
n as a good place for photography.

*Photographs in* 1901.—The photographic work ha
n as usual; 187 chart plates were obtained, an
time was devoted to the comet, but a hazy sk
ade it impossible to get a good photograph, the
og rendering the picture of the comet of no use.
g to the hindrances in making a new form of mea
considerable delay has been inevitable, but the m
is now completed, and is ready for use in measuri

rdinary *screw* used for small measures has be
nd a steel band wound up by a screw contr
er slides.
uantity measured is presented to a microscop
n minutes of arc, seconds and tenths of second
estimating 0″·10. Description and photographs
will be sent as soon as possible.

*ent of the Sydney and Melbourne Plates of the*
*raphic Catalogue. Joint Report for Sydne*
*urne.*

work was carried on by the Measuring Bureau
e Observatory, using the Repsold micrometer de
vid Gill, and the Melbourne filar micrometers r

mining photographic magnitudes will form the subject of a separate paper by the Government Astronomer for Victoria.

*Perth Observatory, Western Australia.*

*Astrograph.*—A start has at last been made in systematic astronomical work. By invitation of the International Committee this Observatory has taken zone $-32°$ to $-40°$ in connection with the Photographic Chart and Catalogue of the heavens. From a variety of causes it was not until the latter part of the year that a real commencement could be made, and even now the percentage of rejected negatives is high. This is due mainly to the difficulty of securing reliable plates. A few blemishes or a certain amount of fogginess do not necessarily cause the rejection of a Catalogue negative, but it is felt that if the chart plates are ever to be reproduced they must have clean glass free from fog or impurities in the film, and we have so far experienced great difficulty in obtaining this result. The number of plates passed so far is sixteen for Chart and twenty-four for Catalogue. The former set contains three images of each star situated at the points of an equilateral triangle, with half an hour's exposure for each. It is not proposed to take any with long single exposures.

*Measurement of Plates.*—No arrangements have yet been made for this, but it is hoped that the Government will shortly authorise the appointment of two ladies, who will undertake the measurements with a machine of the form designed by Professor Turner.

*Transit Circle.*—A working list of three stars per degree, or twelve per plate, has been prepared with the aid of the Cape Durchmusterung, and this will form the principal work for the transit observers. Each star will be observed three times, and we hope to complete a zone of two degrees per year. The work was commenced on 1901 October 6, and by the end of the year we had obtained 1072 observations of zone stars, including the necessary three determinations for 258 stars.

The level and azimuth error and nadir reading are always observed at the commencement and end of each evening's work, and the circle is read by four microscopes.

*Time Service.*—In addition to the zone observations 1052 clock stars were taken for clock error, and instrumental constants were determined as follows :

| | |
|---|---|
| Level ... ... ... ... | 267 |
| Azimuth ... ... ... ... | 316 |
| Collimation ... ... ... ... | 74 |
| Nadir Point ... ... ... | 34 |

The time-ball at Fremantle is dropped daily at 1 P.M. W.A.

time, including Sundays and holidays, and at suc
nay be requested by the commanders of mail-bo
were six failures during the year—three being
on the line, one by a heavy rainfall finding
lectrical machinery, one of the batteries running
due to some undiscovered cause. The control
and railway clocks worked satisfactorily thro

*rological.*—A book on the climate of Western Au
g the results of past observations, and entailing
amount of work, has at last been printed and
ributed. The preparation of this and passing it t
has delayed the publication of the annual rep
ch, however, will shortly be available.
attention has been bestowed, as usual, on
l most of the stations south of the tropics w
y an officer from the Observatory at some time

ily weather forecasts, which are generally looke
blic as the sole reason for the existence of an
ve again been very successful. There are five
hese, viz. : (1) and (2) general forecasts for th
ued at noon and at 8 P.M. respectively ; (3)
the goldfields, issued as above ; (5) special fore
ued at 9 A.M.
llowing were the percentage results for 1901 :—

1 2 3 4

*New Instruments.*—A Milne seismograph was mounted on September 30 in the basement of the dome building, and has been working satisfactorily.

*Lovedale Private Observatory. (Dr. Alex. W. Roberts's.)*

The work of this Observatory during 1901 has been the same as in previous years, viz. the observation of variable stars south of −30° declination.

One hundred stars were under regular observation during the year, the detailed work being as follows :—

| | Stars. | Observations. |
|---|---|---|
| Algol variables ... ... ... ... | 7 | 325 |
| Rapid variables ... ... ... ... | 2 | 371 |
| Short-period variables ... ... ... | 22 | 1740 |
| Long-period variables ... ... ... | 69 | 3609 |
| Total | 100 | 6045 |

Several of the Algol variables were observed with the new prismatic telescope. In this case each observation is the mean of six pointings, the field being rotated through 60° each pointing. The mean relative magnitudes thus obtained are freed from positive error.

It is hoped that these determinations will be of some service in arriving at orbital elements of the Algol stars under observation.

All short-period variables are observed twice, once direct and then with the field inverted. In this case each observation is the mean of two determinations.

The fainter stars are observed with the 3¼-inch Ross telescope, but it is a matter of regret to me that I am unable to follow faint stars below $11^{m}\cdot2$, the limit of the Ross glass. The form of the light curve of a star at its minimum phase is as important as the light curve during the star's maximum.

At the beginning of the year a preliminary paper on the elements of 95 southern variable stars was given in the *Astronomical Journal*, Nos. 491 and 492. A fuller consideration of the observations made at Lovedale, now extending over ten years, will be undertaken when a full series of measures with the new prismatic telescope has been secured.

*Mr. Tebbutt's Observatory, The Peninsula, Windsor, N.S. Wales.*

The following is a statement of the work at this Observatory during the year 1901 :—

*Department.*—

| | | |
|---|---|---|
| ich the time was determined ... ... ... | | 106 |
| of stars with a declination not exceeding −40°... | | 479 |
| of stars in high declination for azimuth ... ... | | 109 |
| terminations of | level error ... ... ... | 288 |
| | collimation error ... ... | 27 |
| | azimuth error ... ... ... | 78 |

as throughout a dry one, and as a consequence the
f the level error were small.

*dian Department.*—The following micrometer com-
made with the equatorials :—

| | Nights of Observation. | Number of Comparisons. | Number of Comparison Stars. |
|---|---|---|---|
| .. ... ... ... | 4 | 54 | 3 |
| .. ... ... ... | 6 | 60 | 2 |
| enope ... ... ... | 9 | 114 | 5 |
| omene ... ... ... | 10 | 136 | 5 |
| ... ... ... | 4 | 47 | 2 |
| 901 ... ... ... | 32 | 273 | 39 |

to the above work twenty-eight southern double
easured, and a few occultations of stars by the
bserved. The usual meteorological observations
n.

## Notes on some Points connected with the Progress of Astronomy during the Past Year.

### *Discovery of Minor Planets in* 1901.

Thirty-six new planets were discovered during the past year, as follows :—

| Provisional Designation. | Permanent Number. | Name. | Date of Discovery, 1901. | Discoverer. | Place of Discovery. |
|---|---|---|---|---|---|
| FV | 464 | ... | Jan. 9 | Wolf | Heidelberg |
| FW | 465 | ... | „ 13 | „ | „ |
| FX | 466 | ... | „ 17 | „ | „ |
| FY | 467 | ... | „ 18 | „ | „ |
| FZ | 468 | ... | „ 18 | „ | „ |
| GB | 469 | ... | Feb. 15 | „ | „ |
| GC | 473 | ... | „ 17 | „ | „ |
| GD | 474 | ... | „ 17 | „ | „ |
| GE | ... | ... | „ 20 | Carnera | „ |
| GF | ... | ... | „ 22 | Wolf | „ |
| GG | ... | ... | „ 22 | „ | „ |
| GJ | 470 | Kilia | Apr. 21 | Carnera | „ |
| GK | ... | ... | „ 24 | Wolf | „ |
| GL | ... | ... | May 21 | Wolf, Carnera | „ |
| GM | ... | ... | „ 23 | Wolf | „ |
| GN | 471 | ... | June 7 | „ | „ |
| GP | 472 | ... | July 12 | „ | „ |
| GQ | 476 | Hedwig | Aug. 17 | „ | „ |
| GR | 477 | ... | „ 23 | „ | „ |
| GT | ... | ... | Sept. 19 | Wolf | „ |
| GU | 478 | ... | „ 21 | Carnera | „ |
| GX | ... | ... | Oct. 11 | Carnera, Kopff | „ |
| GY | ... | ... | „ 11 | „ | „ |
| GZ | ... | ... | „ 13 | Kopff | „ |
| HA | ... | ... | „ 13 | Carnera, Kopff | „ |
| HB | ... | ... | „ 16 | Kopff | „ |
| HC | ... | ... | Nov. 2 | Wolf, Kopff | „ |
| HD | ... | ... | „ 5 | „ | „ |

| nent ber. | Name. | Date of Discovery, 1901. | Discoverer. | Place of Discovery. |
|---|---|---|---|---|
| | ... | Nov. 3 | Kopff | Heidelberg |
| | ... | „ 6 | Wolf | „ |
| | ... | „ 12 | „ | „ |
| 9 | ... | „ 12 | Carnera | „ |
| | ... | „ 16 | „ | „ |
| | ... | Dec. 16 | Wolf | „ |
| | ... | „ 5 | Kopff | „ |
| 5 | ... | Aug. 14 | Stewart | Arequipa |

ould be added the following planet, discovered in announced till after the last Annual Report :—

| | | | | |
|---|---|---|---|---|
| . | ... | 1900 June 28 | Keeler | Lick |

s provisionally designated GH, GS, GW, HG identical with 449 *Hamburga*, 453, 247 *Eukrate*, *a* respectively. FT is not identical with (220) was conjectured last year. HK may be 367 is 202 *Chryseïs*.

, FU, GA, GE, GF, GG, GK, GL, GM do not ent numbers, not having been sufficiently observed. ment of the discovery of GO was cancelled as

ng planets have been named :—

| No. | Name. | No. | Name. |
|---|---|---|---|

The following planets have been observed at one opposition only: (99) *Dike*, (132) *Æthra*, (155) *Scylla*, (156) *Xanthippe*, (157) *Deianira*, (193) *Ambrosia*, (220) *Stephania*, (285) *Regina*, (290) *Bruna*, (293) *Brasilia*, (296) *Phaëtusa*, (309) *Fraternitas*, (310) *Margarita*, (315) *Constantia*.

From this point we omit the names and give number only: 316, 319, 320, 323, 327, 330, 341, 353, 355, 357, 359, 360, 368 383, 392, 393, 394, 395, 396, 398, 399, 400, 406, 408, 410, 411, 413, 414, 417, 421, 422, 426 to 431 (incl.), 436, 437, 438, 441, 448, 450, 452, 455. All the other planets from (1) to (456) inclusive have been observed at two or more oppositions.

We may note the rediscovery last year of the two interesting planets (361) *Bononia*, (401) *Ottilia*. The former has the greatest aphelion distance (viz. 4·74) of the whole family, while the mean motion of the latter (584″) is approximately double that of *Jupiter*.

The planet HN is interesting from its very high south declination (61½°) at discovery, also for its very large eccentricity ($e$=0·38) and its small perihelion distance (1·60). It was near perihelion when discovered, and will probably be altogether invisible at aphelion oppositions.

Dr. Bauschinger, Director of the Berlin Rechen-Institut, has published an interesting table of statistics of the minor planets discovered up to the end of 1900, which completes the first century of our knowledge of them. We give a summary of some of his results.

The ascending nodes show a decided tendency to cluster in the neighbourhood of the ascending node of *Jupiter's* orbit; this is in satisfactory agreement with Newcomb's theoretical results.

Of the inclinations 315 are under 10°, 133 between 10° and 20°, 29 between 20° and 30°, 1 (*Pallas*) over 30°, 107 have the eccentric angle $\phi$ between 0° and 5°, 195 between 5° and 10°, 132 between 10° and 15°, 27 over 15°. There seems a slight tendency for great inclination and great eccentricity to go together, but no connection between eccentricity and mean distance is indicated.

The longitudes of perihelia show a well-marked maximum near the longitude of *Jupiter's* perihelion, and an equally well-marked minimum near the longitude of his aphelion.

The question is discussed whether this could arise from some months being more favourable than others for discovery, but Dr. Bauschinger finds that the phenomenon cannot be thus accounted for and must be real. The fact, however, that September is far the most fruitful month of discoveries receives an explanation; for the rich region of perihelia souths near midnight; in addition to this the weather is usually fine, the nights dark, and the altitude of the ecliptic at midnight considerable.

Newcomb had already deduced theoretically that the perihelia should be more numerous in the neighbourhood of *Jupiter's* perihelion.

g the planets in order of mean daily motion the gaps
d 600″ (that is, three times and twice *Jupiter's* mean
) are very strongly marked ; there are other less
ked gaps.
schinger accordingly divides the family into three

| | | Planets. |
|---|---|---|
| s group with $\mu$ between | 2015″ and 900″ | 108 |
| group ,, ,, | 900 ,, 600 | 337 |
| *ter* group ,, ,, | 600 ,, 400 | 18 |

lows a discussion of the brightness and probable
f the small planets. It is concluded that very few
n the 10th magnitude remain to be discovered, but
nes show no signs of exhaustion.
n albedo is assumed 0·240, midway between that of
*ercury* ; *Mars* is assumed to be of magnitude −1·79
position, and its semidiameter to be 4″·68 at unit
he following equation then gives the radius $\rho$ of a
ometres :

$$\log \rho = 3{\cdot}3135 + \log [a\,(a-1)] - \tfrac{1}{5}\, m_\odot .$$

f double entry is provided, with arguments log $a$ and
the radius of a planet to be at once inferred.
without saying that no stress can be laid on
iameters deduced by this method, since we know
Barnard's measures on the four brightest asteroids

Bauschinger's diameter for *Eros* is 32 km., or 20 miles. It would be 15 miles, using the above formula.

The volume of the 12 largest planets (Nos. 1, 2, 3, 4, 7, 9, 10, 15, 16, 22, 29, 349) forms $\frac{2}{3}$ of the volume of the whole; and since the tiny planets now discovered add so little to the volume, Dr. Bauschinger estimates that the entire family (including those still to be discovered) would form a sphere of radius 660 km., or diameter 830 miles, which would become 610 miles, using the albedo 0·44. This is $\frac{1}{13}$th of the Earth's diameter; and if we estimate the mean density as $\frac{2}{3}$ of the Earth's, the total mass would be $\frac{1}{3300}$ of the Earth's, or $\frac{1}{40}$ of the Moon's.

Such estimates are, however, apt to be fallacious, for there may be numerous planets of considerable relative mass near *Jupiter's* orbit, which are invisible owing to distance.

A. C. D. C.

## *The Planet Eros.*

Observations of this planet for parallax were continued up till April last. There is reason to believe that active progress is being made with the measurement and reduction of the plates, but scarcely anything has yet been published.

Numerous meridian observations have been made of the reference stars, and M. Loewy has already published a preliminary catalogue, which, however, will not be definitely adopted till after the observations of the present season have been included.

The discovery of the variability of the planet in a period of $2^h\ 38^m$ was made by Herr E. von Oppolzer in February last, and confirmed by numerous observers; the range of variability seems to have been more than a magnitude. M. Ch. André considered that two consecutive waves of the variation were not exactly symmetrical, and consequently that the complete period should be taken as $5^h\ 16^m$. This result, while probable, can scarcely be considered as definitely established. There have been three theories to account for the variation :—

(1) That the planet is double, consisting of two bodies revolving almost in contact in a period of $5^h\ 16^m$. Mutual occultations take place when the plane of motion passes through the Earth.

(2) That it is shaped like a dumb-bell; the further suggestion is made that two spherical bodies may have collided and adhered together. Mutual occultations would take place as above when the Earth was in the plane of motion.

(3) That the variation is simply caused by large differences of albedo of various parts of its surface.

All of these hypotheses are open to objection, but it would seem that they exhaust the possible explanations. The fact that the large variation of light was temporary seems to favour (1) or

(2). There is evidence that the variation in 1901 January was much less than in February, and by May 8 it had sunk to zero, according to Professor Wendell, of Harvard Observatory. The Harvard photographs of former apparitions have been examined for variation in light. The range seems to have been very small at the time that the 1893–94 photographs were taken, but larger in 1896 June, when it seems to have been about 1 magnitude.

It is most desirable that accurate observations both of the position and brightness of the planet should be made at every apparition; the former in order to determine the perturbations by the Earth, which will in the course of years give a very reliable value of the solar parallax; the latter to determine the explanation of the light changes. At the next opposition the planet will be too far south for European observation; but observations will be possible next autumn, when the planet will be in perihelion, and consequently nearly as bright as at opposition. The following ephemeris is abbreviated from Harvard Circular No. 61.

| Date. | R.A. h m | Decl. ° | Mag. m | |
|---|---|---|---|---|
| 1902 Sept. 27 | 8 42 | N. 25·0 | 12·45 | |
| Nov. 16 | 11 37 | N. 2·3 | 12·09 | perihelion |
| 1903 Jan. 5 | 14 9 | S. 21·7 | 12·07 | |
| Feb. 24 | 16 30 | 36·1 | 12·11 | |
| Apr. 15 | 18 5 | 43·1 | 11·79 | |
| June 4 | 17 14 | 43·5 | 11·55 | nearest Earth |
| July 24 | 16 21 | 31·1 | 12·41 | |
| Sept. 12 | 17 17 | S. 25·4 | 13·43 | |

A. C. D. C.

## *The Comets of* 1901.

Giacobini's comet, discovered on 1900 December 20, to which reference is made in the last report, and whose orbit seemed likely to prove interesting, has unfortunately been very little observed on account of its extreme faintness. Dr. Aitken observed the comet on February 15 with the 36-inch refractor of the Lick Observatory, but this is an isolated position, measures having generally ceased a month earlier. Dr. Kreutz's short-period ellipse represented the motion of the ellipse in February, but no farther enquiry into the orbit has been made.

The Great Comet appears to have been independently seen at several places in the southern hemisphere. At Paysandu it was reported as early as April 12, and certainly through the latter end of April onwards through May the comet was a most conspicuous object as it swept through the constellations of

*Pisces*, *Eridanus*, and *Orion*, moving nearly parallel to the equator. At the time of the earliest observations the comet was visible only in the morning sky, but after passing perihelion on April 24, it was visible in the evening and attracted considerable attention from the brilliancy of the nucleus and the shape of the tail. The former on May 2 rivalled *Sirius* in lustre, and was distinctly elliptical in shape. The tail has been described as triple, but it is difficult to reconcile that description with the photographs and drawings that have come to hand. The main tail was seen to be divided by a distinct rift, while a quantity of cometic matter near the nucleus varied greatly in brilliancy, suggesting another tail. Major Eddie, who made a study of the comet at Naauwpoort, gives a description of what he saw on May 4, which coincides very closely with the pictures that have arrived from the Cape of Good Hope. "The head was sharply defined on its western periphery, but its following portion was somewhat fuzzy and rugged. The principal tail was sharply defined on its northern border and had a central condensation, also a dark rift, which gave it a bifurcated appearance. The lateral tail was much dimmer and broader and seemed to proceed from behind the nucleus; the cometic matter composing it appeared to be striated, and to be of even luminosity throughout."

The most northern observatory at which the comet was observed was the Lick, and the orbit rests entirely on the measures made in the southern hemisphere. Mr. Merfield, employing three normal places extending from May 6 to June 6, derived a very elongated ellipse, but he appears to prefer a parabolic motion. The perihelion distance, though small, is much greater than is the same element in the family of southern comets from 1843 to 1882, so that no connection is probable between the 1901 comet and the other brilliant visitors of which so many examples have appeared in the last few years.

The only other comet that has been under observation is that of Encke. The preparation of the ephemeris to assist its recovery was undertaken by Dr. Thonberg, of the Kronstadt Observatory, and the comet was found by Professor Wilson, of Northfield, U.S.A., on August 5, very near the predicted place. The earliest observations showed that the mean anomaly required a correction of $-4'\ 24''$, or that the time of perihelion passage was in error about six hours. The path of the comet at first through *Gemini* and *Cancer* allowed observations to be made in the northern hemisphere, but early in September the comet moved rapidly to the south, and was too near the Sun to be visible. In October the comet was south of the Sun and observations were only possible in the southern hemisphere, and details have not yet been published.

To this scanty record of cometary observation must be added the unwelcome fact that two comets have passed through perihelion without being seen. The first of these, that of

was looked for in vain at Arequipa, where a sys
as maintained by means of the Bruce photo

The date of the perihelion passage of Comet
), the other missing comet, is extremely uncert
eeping ephemerides were prepared by Dr. Neu
y without success.

itive elements of several comets have appeared
and in this field of heavy work we may recog
f Mr. C. T. Merfield, of Sydney, who, besides doi
ork in the way of supplying orbits and epheme
hile under observation, has calculated definitive e
s 1898 VII. and 1899 I., both of which are hyp
s of several other comets have been placed in
ry position by the efforts of other computers,
ely that a stimulus will be given to this class
posal of Mr. Lindemann, of Sidmouth, to give a
the satisfactory determination of the orbits o
hich have hitherto been neglected. W.

*Progress of Meteoric Astronomy in* 1901.

*ry Meteors.*—Moonlight and cloudy weather pr
*rantids* being successfully observed in 1901.

*Meteors.*—The shower of *Lyrids* was well s
but on previous nights meteors were rather
e skies were clear and free from moonlight. On A
y rate of apparition of all meteors for a single o

ceased to be traceable after April 20; hence if a real motion of the time was thus indicated in the radiant point's position, it seemed to be onwards in R.A. about 5° on the four nights, April 18–21, along a parallel of declination."

*July and August Meteors.*—Moonlight prevented observation at the close of July and early part of August. At the middle of July the weather was tolerably clear, but meteors were rather scarce. The first *Perseids* were noticed on July 21, when the radiant point of the shower was at 23°+52°. At Bristol the nights of August 10 and 11 were fine, and 172 meteors were observed. August 12, 13, and 14 were cloudy, but an unusually long period of clear weather followed, for the 10 nights from August 15 to 24 offered excellent opportunities for tracing the *Perseid* shower through its later stages, and 220 meteors were observed by Mr. Denning. There were a few *Perseids* visible on every night of the period, and the easterly movement of the radiant was well marked. The maximum of the shower appeared to be attained on the morning of August 13, but the cloudy state of the firmament prevented fair comparisons being made. Mr. Wm. Mitchell, of Maine, U.S.A., saw 42 meteors in the hour between 10 and 11 on August 13, and Mr. R. M. Dole, at Oganquit, U.S.A., counted 79 *Perseids* in 5 hours between 8.30 and 13.30 on August 13, so that the display certainly exhibited unusual strength at a period which we regard as late for the *Perseids*. Miss Bolton, at Leeds, counted 125 *Perseids* on August 10 in $2^h\ 25^m$, while on the night of August 11 119 were noted in slightly less than $2^h$, so the numbers were nearly similar on the two nights. On the whole the display was decidedly richer than that witnessed in an ordinary year, and furnished the usual proportion of large meteors, some of which were registered at several stations and their real paths ascertained. A great number of astronomers, at home and abroad, participated in the observations, but it is impossible to refer to their individual results, many of which have already been published in *Astronomische Nachrichten*, *Nature*, *Popular Astronomy*, *Journal of the B.A.A.*, *English Mechanic*, and other serials.

*October Meteors.*—This shower was fairly well seen at several stations, but it was not of special character. As observed at Bristol on the night of October 20, the principal radiant was at 99°+13°, as on 1900 October 23. Formerly the chief centre was at 92°+15°, and it will be important to watch the *Orionids* thoroughly during the ensuing few years to ascertain whether the stronger shower emanates from *ν Orionis* or *ξ Geminorum*. Mr. R. M. Dole, at Jamaica Plain, Mass., kept a watch on October 19 between $13^h$* and $16^h\ 15^m$,* and observed 89 meteors: 55 of these were from the *Orionid* radiant, 11 from *Gemini*, 8 from *Taurus*, 3 from *Leo*, 5 from *Perseus*, and 4 from *Aries*. The

* In all cases local times are given. This description and some others relating to the *Leonids* are condensed from *Popular Astronomy*.

n was attained at $13^h\ 40^m$–$13^h\ 50^m$. There wer
neteors ; one from *Pegasus* lit up earth and sky l
on, and curved as it died out so that it made
Two of the meteors from *Gemini* started as li
d as they shot. One, which was as bright as
riangle ; another ended in a burst about 1° in di
*nids* came in shoals with a maximum every 20 m
*nber Meteors.*—The *Leonids* were not expected to
al numbers in 1901, but the shower was very ge
or, and the weather being favourable just at t
ime the results obtained were satisfactory if the
tional. The display was well marked, but it
the maximum occurred after sunrise in Engl
r 15, so that the results obtained in this country
a parallel with those coming from America. The
few extracts from the descriptions of the shower

| | Date. | Time of Watch. | Duration. | Leonids. |
|---|---|---|---|---|
| | | h m h m | h m | |
| hel, | Nov. 14 | 11 to $15\frac{1}{4}$ | $4\frac{1}{4}$ hrs. | 6 |
| | 15 | $12\frac{1}{2}$ „ $15\frac{3}{4}$ | $3\frac{1}{4}$ „ | 12 |
| er, | Nov. 14 | 14 37 „ 16 22 | 1 45 | 18 |
| igh | 15 | 16 55 „ 18 0 | 1 5 | 6 |
| , | Nov. 14 | 12 22 „ 15 0 | 2 10 | 20 |
| er | 15 | 13 20 „ 17 0 | 2 30 | 51 |
| | Nov. 14 | ... ... | 1 30 | 37 |

In America meteors were much more plentiful. At Carlton College, Northfield, Minn., one observer watched the sky on November 14 from $12^h\ 30^m$ to $17^h\ 50^m$, and during this interval of $5^h\ 20^m$ counted 621 meteors. For an hour before $15^h\ 30^m$ 124 were seen; from $15^h\ 30^m$ to $16^h\ 30^m$, 209; and from $16^h\ 30^m$ to $17^h\ 30^m$, 187. Another observer during the latter period counted 100 meteors in 27 minutes, none of which were less in brightness than a star of mag. 2. Mr. Payne estimates that four observers might possibly have counted 1600 meteors (large and small) per hour. Several brilliant fireballs were noted. Mr. Winslow Upton, of the Ladd Observatory, Providence, gives the following numbers :—

| | h | m | | h | m | Leonids. | Sporadic. |
|---|---|---|---|---|---|---|---|
| Nov. 14 | 15 | 0 | to | 15 | 30 | 34 | 1 |
| | 15 | 30 | „ | 16 | 0 | 58 | 7 |
| | 16 | 0 | „ | 16 | 30 | 61 | 7 |
| | 16 | 30 | „ | 17 | 0 | 66 | 7 |
| | 17 | 0 | „ | 17 | 30 | 60 | 8 |

There were about 2 *Leonids* per minute between $15^h\ 30^m$ and $17^h\ 30^m$.

Mr. E. L. Larkin, at Echo Mountain, Virginia, maintained a watch on the night of November 14, with the following results :—

| | h | m | | h | m | Meteors. |
|---|---|---|---|---|---|---|
| Nov. 14 | 12 | 0 | to | 13 | 0 | 32 |
| | 13 | 0 | „ | 13 | 54 | 27 |
| | 13 | 54 | „ | 14 | 43 | Clouds |
| | 14 | 43 | „ | 15 | 0 | 19 |
| | 15 | 0 | „ | 16 | 0 | 173 |
| | 16 | 0 | „ | 17 | 0 | 297 |
| | 17 | 0 | „ | 17 | 40 | 109 |

Thus between $16^h\ 0^m$ and $17^h\ 0^m$ meteors appeared at the rate of 5 per minute. The estimated brightness of about one-third of the total number seen was as under :—

| | Meteors. |
|---|---|
| Twenty times brighter than *Venus* ... ... | 2 |
| Ten „ „ „ ... ... | 3 |
| Five „ „ „ ... ... | 12 |
| Equal to *Venus* ... ... ... ... | 25 |
| „ *Jupiter* at maximum ... ... | 40 |
| „ *Sirius* ... ... ... ... | 20 |
| „ *Rigel* ... ... ... ... | 120 |

The streak of one meteor remained visible for 14 minutes; of another, 6 minutes. The magnitudes summarised above show that a large proportion of the visitors were brilliant, yet Mr. Winslow Upton, whose results, obtained at Ladd Observatory, have already been quoted, says that a few only of the meteors seen by him were brighter than stars of the 1st mag.

Mr. W. C. Brenke, at the Observatory of Illinois, reports that three observers there counted 433 meteors on November 14, $13^h\ 30^m$ to $17^h\ 30^m$. The maximum was between $17^h$ and $17^h\ 5^m$ when the rate of apparition was 288 per hour.

Mr. R. M. Dole, of Jamaica Plain, Mass., counted the following numbers :—

| | h | m | | h | m | Leonids. | Others. |
|---|---|---|---|---|---|---|---|
| Nov. 14 | 15 | 0 | to | 16 | 0 | 43 | 0 |
| | 16 | 0 | „ | 17 | 0 | 74 | 4 |
| | 17 | 0 | „ | 18 | 0 | 48 | 4 |

The maximum was from $16^h\ 30^m$ to $17^h$. Three of the meteors were brighter than *Venus*, 2 equal to *Venus*, and 26 equal to *Jupiter*. Mr. W. P. Russell, in Illinois, on November 14, $17^h\ 36^m$ to $17^h\ 40^m$, observed 13 *Leonids*; so the rate of apparition was about 3 per minute. Mr. J. Salloms, at Dunmore, British America, on November 14, $16^h\ 30^m$ to $17^h\ 30^m$, counted 186 meteors, or 3 per minute. At $16^h\ 10^m$ a brilliant *Leonid* travelled from the Sickle to N.W., and left a streak for 20 minutes. Mr. Salloms remarks that the great majority of the meteors appeared to reach points near the horizon before being extinguished.

The display in America would appear to have been pretty rich, on the mornings of both November 15 and 16. A telegraphic despatch from Phœnix states that a shower of great brilliancy occurred on the morning of November 16. In 30 minutes one observer counted 200 meteors. At Los Angeles the fall of *Leonids* was quite marked before daylight on November 16. In the hour from 4 to 5 A.M. one observer saw 385 meteors.

*December Meteors.*—The *Geminids* seem to have been less active than usual. On December 10, $9^h\ 50^m$ to $10^h\ 30^m$, Mr. T. H. Astbury, at Wallingford, saw 6 meteors, including 2 *Geminids*. Later on the same night, at Bristol, about 17 meteors were recorded in two hours, but there were only 1 or 2 *Geminids*.

Mr. W. E. Besley, of London, watched the sky on December 10 between $11^h\ 12^m$ and $13^h\ 22^m$ and recorded 21 meteors, of which about 9 were *Geminids* from a radiant at $104° + 29°$.

Mr. P. M. Ryves, observing near Exeter on December 10, between $11^h\ 45^m$ and $14^h\ 15^m$, saw 54 meteors, of which 27 were *Geminids*. He noticed that some very rapid small meteors radiated from *Leo Minor* or *Ursa Major*. The sky was very clear, with the exception of a few small clouds which did not materially interfere with observation.

The following is a list of the real paths of bright meteors observed in England during the past year :—

| Date. 1901. | G.M.T. h m | Brightness. | Height at First. Miles. | Height at End. Miles. | Length of Path. Miles. | Velocity per Sec. Miles. | Radiant Point. α ° | Radiant Point. δ ° | Observers. |
|---|---|---|---|---|---|---|---|---|---|
| Jan. 13 | 10 35 | F | 61 | 52 | 54 | 8 | 149 | −12 | 3 |
| 28 | 9 18 | ½ = ☽ | 76 | 16 | 61 | 18 | 106 | +52 | 4 |
| Feb. 13 | 10 41 | ♀ | 56 | 26 | 36 | moderate | 72 | +41 | 2 |
| 27 | 8 52 | F | 103 | 57 | 120 | 12 | 165 | + 6 | 3 |
| Mar. 6 | 7 25 | F | 84 | 27 | 66 | slow | 51 | +43 | 8 |
| April 1 | 9 44 | F | 69 | 12 | 67 | slow | 129 | +25 | 7 |
| 19 | 9 28 | ♀ | 56 | 52 | 40 | 25 | 226 | −17 | 3 |
| Aug. 11 | 11 2 | 2 + ♀ | 95 | 56 | 64 | rapid | 45 | +58 | 5 |
| 15 | 10 48 | ♃ − ♀ | 81 | 61 | 37 | 41 | 52 | +53 | 2 |
| Sept. 14 | 8 45 | > ♀ | 66 | 26 | 83 | 20 | 345 | + 1 | 20 |
| Nov. 10 | 6 45 | ½ = ☽ | 64 | 55 | 73 | 24 | 55 | + 7 | 10 |
| 13 | 6 53 | ½ = ☽ | 90 | 52 | 165 | 33 | 87 | +31 | 3 |
| 23 | 10 27 | 3 + ♀ | 70 | 25 | 57 | slow | 65 | +23 | 3 |
| Dec. 4 | 5 36 | = ☽ | 91 | 50 | 64 | 21 | 263 | +36 | 62 |
| 16 | 5 45 | ½ = ☽ | 68 | 54 | 51 | 20 | 105 | +37 | 3 |

The letter "F" in the column headed "Brightness" signifies that the object was a fireball with a brilliancy differently estimated by various observers.

A few of the principal meteoric showers observed during the year were as under :—

| Date. | Radiant. α ° | Radiant. δ ° | No. of Meteors. | Observer. | Name of Shower. |
|---|---|---|---|---|---|
| Apr. 20–21 ... | 261 | +36 | 8 | W.F.D. | |
| 21 ... ... | 270 | +33 | 25 | „ | *Lyrids* |
| July 19–24 ... | 290 | +24 | 8 | „ | |
| Aug. 10 ... ... | 44 | +58 | 55 | „ | *Perseids* |
| „ ... ... | 43 | +56 | 15 | H. J. Townshend | „ |
| 10–20 ... | 335 | +73 | 13 | W.F.D. | |
| 10–21 ... | 290 | +53 | 10 | „ | |
| 10–21 ... | 350 | −14 | 10 | „ | |
| 10–22 ... | 335 | + 1 | 15 | „ | |
| 10–22 ... | 310 | +61 | 11 | „ | |
| 11 ... ... | 45 | +58 | 49 | „ | *Perseids* |
| „ ... ... | 46½ | +57 | 14 | A. King | „ |
| 11–12 ... | 50 | +58 | 30 | W. H. Milligan | „ |
| 12 ... ... | 45 | +54 | 10 | H. J. Townshend | „ |
| „ ... ... | 47 | +58 | 13 | A. King | „ |

| Radiant. $\alpha$ | Radiant. $\delta$ | No. of Meteors. | Observer. | Name of Shower. |
|---|---|---|---|---|
| .. 152° | +23° | 12 | J. H. Bridger | *Leonids* |
| . 150 | +23 | ... | E. C. Willis | ,, |
| . 149 | +23 | 6 | A. S. Herschel | ,, |
| . 150 | +23 | 12 | ,, | ,, |
| .. 150 | +22 | ... | T. H. Astbury | ,, |
| . 150¾ | +21½ | 88 | W. Upton | ,, |
| .. 151 | +21¼ | 21 | ,, | ,, |
| . 149 | +22¾ | 7 | W. H. Robinson | ,, |
| .. 151 | +23 | 19 | W. C. Brenke | ,, |
| .. 149 | +24 | 63 | ,, | ,, |

e shower of *Leonids* was a moderately rich one the esults appear to have been very meagre. Mr. H. ured one *Leonid* trail at Northfield, Minn., and others obtained in 1898 appear to prove that the an area, but a point at $\alpha$ 10$^h$ 6$^m$, $\delta$ +22° 18′.

mbia College Observatory Professor J. K. Rees e plates taken on November 14 show a number of g a remarkable one left by a brilliant *Leonid* d on November 14, 15$^h$ 58$^m$, and left a streak for

W. H. Pickering, of Harvard, remarks (*Popular* 02 January) that the observations of the *Leonids* r to induce the belief that the 33·25-year period

daytime showers while making solar observations, and noticed that the irregular rate and direction of motion of the objects, combined with their aspect and general behaviour, proved them to be sunlit, comparatively near the Earth's surface, and borne along in wind currents which introduced all the vagaries observed. W. F. D.

## *Solar Activity*, 1901.

There can be little doubt that the past year has seen the minimum of the current solar cycle. As it regards both spots and faculæ, the Sun has been more entirely quiet than in any year since 1878. On 297 days out of the 365 it was entirely free from spots—that is to say, on 81 per cent. as compared with 50 in the previous year. Only two groups of any importance were noted, both of which formed on the farther side of the Sun, and came into view first at the east limb. The first of these appeared by a curious coincidence on the day after the total solar eclipse, a great prominence over the place of the spot having been conspicuous during the eclipse. This group was visible during two apparitions, being seen from May 19 to May 30, and again from June 16 to June 26, though in much diminished extent. A fine regular spot ran its course from November 13 to November 25. The other groups were all insignificant and short-lived. The longest periods of complete quiescence were from March 11 to May 18, 69 days; and from July 25 to October 6, 74 days. The mean daily spotted area for the year will scarcely exceed, if indeed it does at all, that for 1878, which was twenty-four millionths of the Sun's visible hemisphere, or one-sixtieth of that shown during the last maximum.

*The Prominences.*—The slight falling off in the mean daily numbers of prominences which was noticed in 1900 appears to have continued and to have become much more marked during 1901.

The results derived from observations carried out on a uniform plan at Kenley for the two years are as follows :—

| | 1900. Per diem. | 1901. Per diem. |
|---|---|---|
| North hemisphere | 3·17 | 2·56 |
| South „ | 3·61 | 3·06 |
| Total mean number | 6·78 | 5·62 |

The average size of the prominences also shows a decrease in the ratio of five to four.

The southern hemisphere still continues to be more active than the northern in the proportion, roughly, of six to five; and the distribution of the prominences in latitude during 1901 shows but little change compared with the previous three or four years. By far the largest number have occurred between the

of +35° and +55° in the northern hemispher
−45° and −55° in the southern hemisphere,
naximum activity occupying nearly the same po
o. The southern zone has, however, encroached
on the barren polar region, and the parallels +6
mark symmetrically the limits of prominence ac
ne poles.

Fenyi, at Kalocsa, records seventeen prominences
100″ in height observed during the year; ar
on June 1, which attained the height of 4
nutes.

rge prominences of the eruptive class were s
nd only one metallic prominence was recorded
n January 20 in latitude −6°. E. W. M. and

*Total Solar Eclipses.*

1898 *January 22.*

mportant papers on the spectroscopic results ob
lipse, by Sir N. Lockyer and Mr. Evershed, hav
during the year. (*Phil. Trans.*, 197A.)

Lockyer discusses the spectra of both the coro
nosphere, and arrives at the conclusion, confir
reviously expressed opinion, that many very
heric lines are not represented among the Frau
*vice versâ*, and that the chromosphere is, therefo

of which the strongest arc lines are visible in the chromosphere spectrum and some of its lines have long since been observed thickened over spots. The presence of barium in the chromosphere, among elements of much lower atomic weights, seems quite analogous to the extended diffusion of calcium, and neither phenomenon presents any difficulty if we admit a dissociation theory.

1901 *May* 18.

The observations of this eclipse, which, owing to the long duration of its totality, was looked forward to with unusual interest, proved somewhat disappointing, as the weather conditions were decidedly unfavourable. Three British parties took part, Mr. Newall from the Joint Permanent Eclipse Committee, and Mr. Dyson and Mr. Maunder from the Royal Observatory, and a preliminary account of their results has been published.

Mr. Newall, who was stationed at Sawah Loento, in Sumatra, attempted an extensive series of observations, including photographs of the corona both direct and with a polariscopic camera, spectrum photographs with flint, quartz, and grating spectrographs, and a further attempt to get some indication of the rotation of the corona by measuring its velocity in the line of sight. Light clouds obscured the Sun at the time of totality, and the spectrum photographs were thus prevented from being completely successful, though some interesting plates were secured, which will doubtless prove worthy of detailed study. The amount of cloud was not sufficient to seriously affect the direct photographs of the corona, of which a good series was obtained. The corona proved to be of the typical Sun-spot minimal type, with extensive polar streamers round the south pole and shorter ones round the Sun's north pole. The most striking feature is the great disturbance that was evident in the eastern equatorial region, where there was a series of remarkable arches presenting an appearance of connection with a large prominence.

Mr. Dyson, who was assisted by Mr. J. J. Atkinson, was stationed on a small island off the coast of Sumatra and had with him the Thompson coronagraph, some of the slides of which were provided with an occulting shutter of the type used in former eclipses by Mr. Burckhalter, and flint and quartz spectroscopes as used before in India in 1898 and in Spain in 1900. Here also light cloud somewhat vitiated the observations, though apparently no very extensive damage was done to the direct photographs. The results obtained with the spectroscopes do not appear to exhibit any novel features. The corona spectrum shows no new lines, and the chromospheric spectra are of the same character as observed before.

Mr. and Mrs. Maunder were stationed on the island of Mauritius, and in conjunction with the staff of the Royal Alfred

Observatory undertook an extensive programme, chiefly in the form of coronal photographs, with instruments of varying focal length and aperture. Though there was no actual cloud, the definition is described as having been very poor, and a considerable amount of "boiling" was observed at the Sun's limb previous to totality. A large number of successful photographs were, however, obtained.

If the British observers were unfortunate in the weather, the American parties were still more so, and the large expedition from the U.S. Naval Observatory, including in their number Professor Barnard, found their view of totality entirely obscured by clouds. This is all the more to be regretted seeing that Professor Barnard had made preparations for obtaining coronal photographs with a lens of 61½ feet focal length, using plates 40 inches square. With the long exposure that could have been given and Professor Barnard's well-known photographic skill, it is certain that the resulting pictures would have been of exceptional interest and beauty.

The Naval Observatory party had also detachments at two other places, which were more fortunate than the main body. Professor Eichelberger, Dr. Humphreys, and Mr. Peters were at Fort de Kock, the only station in Sumatra where the weather was perfectly clear, and the last-named observer is known to have secured a good set of photographs with a 40-foot telescope. The Lick Observatory party, under the direction of Professor Perrine, was at Padang with an extensive equipment comprising Professor Schaeberle's 40-foot telescope, spectrum, and polariscopic cameras, and a battery of cameras for detecting the presence of an intra-mercurial planet. The long totality of this eclipse made it a unique opportunity for this search, and in spite of the presence of cloud some interesting evidence, apparently all of a negative nature, was obtained. Professor Perrine reports that the best plate showed 37 stars down to about 8·6 visual magnitude, and another one 28 stars down to magnitude 8·8. The failure to find a new planet will not, however, cause any surprise, as, seeing the close scrutiny to which the surface of the Sun has been subjected for many years, and seeing that it is almost inconceivable that a planet inside *Mercury* should not transit the Sun's disk at comparatively frequent intervals, it seems highly improbable that such a body could have escaped detection.

The spectrum photographs taken by this party show a strong Fraunhofer dark-line spectrum in the outer region of the corona, an appearance often before observed, especially when using instruments of considerable light grasp and small dispersion. Professor Perrine considers that his results indicate that the light of the outer corona is almost entirely reflected sunlight, while that of the inner corona emanates from incandescent matter; and he thence concludes that the extensions and streamers are due to matter ejected radially from the Sun at high velocities, such matter being gaseous and incandescent while near the solar

surface and becoming solid at a certain distance. He thus arrives at a theory of the corona similar to that originally propounded by Schaeberle. In connection with this question it may, however, be remarked that previous observers, basing their opinions upon a discussion as to the position in the spectrum of the point of maximum photographic intensity of the coronal light, have reached the conclusion that only a small portion of the light, even of the outer corona, is due to sunlight reflected from small particles, and are thus at variance with Professor Perrine. Another American party, from Amherst College, under the direction of Professor D. P. Todd, were located in Sumatra with an elaborate battery of instruments, but were unfortunate in their weather and obtained but meagre results.

A French party, under the direction of the Comte de la Baume Pluvinel, was at Padang and made some successful observations. No detailed report of their work has, however, yet been published. The same may be said of the large party of Dutch astronomers, and also of the Russian and Japanese observers.

In conclusion, we may say that this eclipse marks little, if any, advance in our knowledge of solar physics. The spectrum photographs secured are apparently not so good as those got either in 1900 or in 1898, and, while detailed examination may reveal points of interest, it is not probable that this scrutiny will reveal anything of fundamental importance. The apparent inter-relation between a disturbed region of the corona and a prominence is interesting, as any connection between the two phenomena was not previously established with certainty, and may serve to throw some light on the physical constitution of the corona.

E. H. H.

## *Nova Persei.*

A new star was discovered in *Perseus* on February 21, $14^h\ 40^m$ G.M.T., by Dr. Anderson, of Edinburgh. It was then of 2·7 magnitude and shone with a bluish-white light. Its approximate place for 1901·0 was R.A. $3^h\ 24^m\ 25^s$, Dec. $+43°\ 41'$. The news was telegraphed to Kiel and appears to have been circulated to most European observatories, and to that of Harvard College for distribution in America by the early evening of February 22.

The star was seen on February 22 (before news of its discovery by Dr. Anderson had reached them) by Mr. Gregg at Hastings, Mr. Gore at Dublin, Mr. Laursen-Nordvig in Denmark, Messrs. Baliasny, Kvasnikoff, and Sviatsky near St. Petersburg.

Of more interest is the announcement by Dr. Glasenapp that the star was seen on February 21, $9^h\ 50^m$ G.M.T., by Mr. Borisiak, a boy of sixteen, at Kiew, who gave the magnitude as 1·5, and wrote to Dr. Glasenapp before the news could have reached Kiew. At the instance of the editor of the *Astronomische*

*Nachrichten* enquiry was made as to whether any mistake in date could have been made, and he was satisfied that the only error made was in the magnitude of the star, which was probably over-estimated.

*Magnitude.*—At discovery by Dr. Anderson the magnitude was $2^{m}\cdot7$. Three observers, Messrs. Grimmler, Plassmann, and Schwab, state they were observing the part of the sky in which the Nova appeared on February 21 from $7^{h}$ to $10^{h}$ $30^{m}$, and consider that the star would not have escaped their notice had it then exceeded $3^{m}\cdot4$. Against this must be set Mr. Borisiak's observation given above. No trace of the star is shown on Harvard College photographs taken on February 18 and 19, which showed stars down to $10^{m}\cdot4$, and a photograph taken by Mr. Stanley Williams on February 20, $11^{h}$ G.M.T., only 28 hours previous to Dr. Anderson's discovery, showed stars of $11^{m}$ to $12^{m}$, but did not show the Nova.

From February 23 onwards hundreds of observations have been made of the magnitude of Nova *Persei*, and are to be found in the astronomical periodicals and in the circulars of the Lick and other observatories. The light curve from February 19 to April 30 determined from 527 observations, mostly published in *Astronomische Nachrichten* and *Bulletin de la Soc. Astron. de France*, is given by Mr. Child (*Monthly Notices*, vol. lxi. p. 483). A collection of the observations as well as a diagram of the light curve is given by Mr. Wilson in *Popular Astronomy*, vol. ix.

The most complete discussion of the magnitudes yet published is given by the Rev. J. G. Hagen, S.J., as supplementary notes to the "Atlas Stellarum Variabilium" of the Georgetown College Observatory. The new star, which, on February 20, $11^{h}$, was $<11^{m}$, and was $2^{m}\cdot7$ on February 21, $14^{h}$ $40^{m}$, rapidly increased to $0^{m}\cdot1$, which it appears to have reached by February 23, $5^{h}$ G.M.T., and to have remained at this magnitude for about 24 hours. Its magnitude then diminished, at first rapidly and afterwards more slowly, so that it was $1^{m}\cdot0$ about February 25, $7^{h}$ G.M.T., $2^{m}\cdot0$ on March 1, $3^{m}\cdot0$ on March 10 or 11, and $4^{m}\cdot0$ on March 18. The further decline to $6^{m}\cdot0$, which was reached early in June, was accompanied by oscillations sometimes reaching to nearly two magnitudes, and of period varying from two to five days. The first pronounced *minimum*, though smaller oscillations may have occurred earlier, was on February 19, when the magnitude was $5^{m}\cdot2$. Other minima were on March 22, 25, 28, &c. These oscillations do not seem to have been maintained to any great extent after the early part of June, though as yet the observations have not been collected and discussed. The diminution of magnitude continued slowly to the end of the year, when the Nova was $7^{m}\cdot0$ or a little brighter.

*Colour.*—An account of the change of colour of Nova *Persei* from February 22 to April 30 is given by Mr. Osthoff in *Astronomische Nachrichten*, 3751. The colours attributed by different observers till May are given in *Popular Astronomy*. At its dis-

covery Dr. Anderson described the colour as bluish-white. There is some divergence among the observers, but it would seem that on February 23 and 24 it was white, a pale yellow on February 25 and 26, becoming orange by the beginning of March and red by March 3 or 4. From March 19, when the oscillations in magnitude began, the colours were orange at a maximum and red at a minimum. It may be noticed that the photographic image of the star was much stronger than that of a red star of similar visual magnitude, possibly in consequence of the large amount of ultra-violet light as shown in the spectrum. According to a paper of Mr. Robinson's (*Monthly Notices*, vol. lxii. pp. 193–199), the changes in photographic magnitude followed closely those of visual magnitude.

*Measures of position; proper motion; parallax, &c.*—The Nova appears to have been observed with the meridian instruments of nearly every observatory soon after the announcement of its discovery. Measures of its distance from neighbouring stars were made at the Yerkes and Lick Observatories, and photographs of the field for use in determination of the position, proper motion, and parallax appear to have been generally taken. As yet there has not been time for any complete discussion, but it appears probable from the results of Mr. Bergstrand and others that the star can have but a very small parallax, probably beyond the limits of measurement. It was announced by Mr. Bergstrand that the Nova had a considerable proper motion, but his later photographs do not support this view. In this connection attention may be drawn to Mr. Ceraski's note in *Astronomische Nachrichten*, 3755, that a photograph taken 1899 January 30 showed a 12th-magnitude star whose co-ordinates relatively to the present position of the Nova are $+0^s{\cdot}31$ in R.A. and $-7''$ in Dec. This star has not been seen since the Nova appeared.

*Spectroscopic observations.*—The spectrum of the Nova has been observed and discussed in the *Monthly Notices* by the Rev. W. Sidgreaves and by Mr. McClean, in the *Proceedings* of the Royal Society by Sir N. Lockyer, in the *Astrophysical Journal* by Professor Hale and Professor Vogel, in a circular of the Lick Observatory (republished in *Astroph. Journal*) by Professor Campbell and Mr. Wright, in Harvard College Circulars by Professor Pickering, and in the *Astronomische Nachrichten* by Mr. v. Gothard.

The earliest photographs of the spectrum of Nova *Persei* were obtained at Harvard College on February 22. The star had a strong continuous spectrum and was traversed by thirty-three dark lines. The general appearance was that of the *Orion* type of stars. The spectrum was similar on February 23, but on February 24 the spectrum was a strong continuous spectrum traversed by bright lines accompanied on the violet side by very broad absorption bands. The contrast between the bright and dark bands was much stronger on February 25, on which day it

l that of Nova *Aurigæ* at the time of its disco
ht bands at H and K were crossed by fine
ium), and a bright band at D was crossed by fine
$D_1$ and $D_2$ (sodium). These lines were only slightly
nd indicated a small velocity of recession. The ma
ght bands $H_\beta$, $H_\gamma$, $H_\delta$ were displaced 8 tenth metr
, according to the measures of Professor Campbell
ght. The changes in the appearance of the spec
ruary 27 to March 28 are shown in photographs g
sor Hale in *Astroph. Journal*, p. 238, the most rem
g the diminution of the bright lines on the red si
e dark bands accompanying the bright bands
by March 13 to numerous fine lines, of which
had the greatest wave length, and was at the ed
nt lines. The bright hydrogen lines were disp
enth metres to the red. The dark hydrogen bands
nd K bands (while they lasted), and the dark so
e all displaced to the violet by an amount $\Delta\lambda = -$'o
l and Wright).
pectra underwent periodic changes in accordance
es in the star's brightness. At a maximum the
pectrum was stronger relatively to the bands. T
re shown in Father Sidgreaves' paper in *Monthly No*
6.
ly 9 it was announced by Professor Pickering that
of the Nova was that of a nebula and showed the
nes.
ctrograph obtained at Lick on July 15 along wi

amounting to no less than 11′ a year. This result was independently obtained by Mr. Ritchey from a photograph taken on November 9. In the *Astrophysical Journal*, vol. xiv., reproductions are given of photographs obtained at Yerkes on September 20 and November 13, which show these remarkable changes in the clearest manner.

The velocities indicated taken in connection with the probable small parallax of the Nova are comparable with the velocity of light. Mr. Max Wolf pointed out in *Astronomische Nachrichten*, 3753, that an assumption of a linear velocity equal to the velocity of light would imply a parallax of 0″·012. He threw out the suggestion that the luminosity was caused by the progress of an electric wave through nebulous matter at rest. Professor Kapteyn in *Astronomische Nachrichten*, 3756, offered as an explanation that the light from the star was reflected to us by the nebulous matter, and that the photographs show the light travelling out from the star.

Suggestions have also been made that an explanation of these high velocities is to be sought in the recent physical discoveries associated with the names of Professor Thompson and Sir W. Crookes. Other astronomers are of opinion that though the velocities are extremely great for ordinary matter, they are not inconceivably so when the extraordinary character of the Nova is contrasted with the everyday phenomena of solar prominences.

*Conclusion.*—It is too soon to enter into the hypotheses which have been put forward to explain the genesis and the subsequent behaviour of Nova *Persei* and of new stars in general. The questions are still *sub judice*. It may be remarked, however, that facts relating to Nova *Persei* have been collected in great volume and importance. The observations of the spectrum at an early date while the brightness was still increasing, the many observations of the spectrum since this time, and the discovery of the nebula in particular have put astronomers in possession of much fuller and completer data for attacking the interesting and difficult questions incident to the formation of *New Stars*. F. W. D.

## *Double Stars.*

The present summary of references is arranged, as in former years, under the two heads, "Observation" and "Calculation." Abbreviated titles have been used as follows :—

*M. N.: Monthly Notices, R. A. S.*
*A. N.: Astronomische Nachrichten.*
*A. J.: Astronomical Journal.*
*A. S. P.: Astronomical Society of the Pacific.*
*L. O. B.: Lick Observatory Bulletin.*
*P. A.: Popular Astronomy.*

*tion.*—Measures of some stars of special intere

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. R. G. Aitken, *A. S. P.* 79; *L. O. B.* 11.
. R. G. Aitken, *A. S. P.* 79; *L. O. B.* 11.
. R. G. Aitken, *A. S. P.* 79; *L. O. B.* 11.
W. Hussey, vol. v. *Lick Publications.*
. R. G. Aitken, *L. O. B.* 11.
T. Lewis, *M. N.* 1901 May.
W. Bryant, *M. N.* 1901 May.
W. Bowyer, *M. N.* 1901 May.
. R. G. Aitken, *L. O. B.* 11.
H. Struve, vol. xii. *Poulkova Publications.*
T. Lewis, *M. N.* 1901 May.
W. Bryant, *M. N.* 1901 May.
W. Bowyer, *M. N.* 1901 May.

*le Stars*—
*Hussey.* *A. J.* 494. Third Catalogue of new d
nder 1″·0.
*Hussey.* *P. A.* 1901 Feb., finds the principal
ose double.
*Hussey.* *A. S. P.* 80, finds principal star of 66
ble (0″·2); also of Σ 2339, which is 0″·2.
*Hussey.* *L. O. B.* 12. Fourth Catalogue of 1c
67 pairs under 1″·0.
*Aitken.* *L. O. B.* No. 3. Third Catalogue c
rs. 43 pairs under 1″·0. The mean results a
731.

*E. Doolittle.* Measures of 900 double and multiple stars made at the Flower Observatory.

*Hermann Struve.* Measures of 900 double stars made with the 30-inch Poulkova refractor from 1885 to 1895. Vol. xii. series ii. *Poulkova Publications.* 76 stars under 0″·5; 127 between 0″·5 and 1″·0; 164 between 1″·0 and 2″·0; the remainder being over 2″.

*Calculation.*—The following papers dealing with calculation and general literature have appeared in the course of the year :—

| | |
|---|---|
| *ζ Sagittarii* | R. G. Aitken, *P. A.* 1901 Feb.; orbit, period 21·2 years. |
| *ξ Boötis* ... | G. C. Comstock, *A. J.* 503; orbit, period 172 years. |
| *η Cassiopeiæ* | G. C. Comstock, *A. J.* 512; orbit, period 500 years. |
| Σ 3062 ... | J. Larsen, *A J.* 505–6; orbit, period 114·2 years. |
| Σ 1639 ... | T. Lewis, *M. N.* 1902 Jan.; orbit, period 180 years. |
| β 107 ... | S. W. Burnham, *P. A.* 1900 Dec ; Note on. |
| *β Cassiopeiæ* | S. W. Burnham, *P. A.* 1900 Dec.; Note on. |
| β 182 ... | S. W. Burnham, *P. A.* 1900 Dec.; Proper motion of. |
| Σ 325 ... | W. Hussey, *P. A.* 1901 Feb.; principal star has a proper motion of 0″·16 in 302°. |

Special mention must be made of vol. v. of the *Lick Observatory Publications.* In this volume Professor W. Hussey has collected all the Otto Struve pairs (OΣ) in order, and gives the whole history of each pair, its catalogue place, the micrometric measures (with references to original sources), and, where possible, a discussion of these measures, accompanied with diagrams, which are also valuable as enabling observers to tell at a glance what stars require observation. Beyond the actual collection and arrangement of measures of other observers, Professor Hussey has examined in all 612 stars, made measures of 547 of them, and found 65 to be single. The work is modelled on the Yerkes volume, and is, like it, a standard of reference.

T. L.

## *Photometry and Variable Stars.*

The past year has been characterised by great activity in the department of variable stars, and the following new variables have been announced. The list does not pretend to be exhaustive.

| tion. | R.A. h m | Dec. ° ′ | Epoch. | Discoverer. | e |
|---|---|---|---|---|---|
| Andromedæ | 0 43·5 | +33 35 | 1855 | Anderson | *A.* |
| Persei | 3 2·7 | +44 29 | 1900 | Guthnick | „ |
| | 3 17·8 | +43 39 | 1855 | Williams | „ |
| „ | 3 24·8 | +44 19 | 1890 | Deichmüller | „ |
| Aurigæ | 5 18·3 | +42 18 | 1855 | Williams | „ short |
| | 10 16·7 | −41 44 | 1875 | Roberts | *A.* Alg |
| Herculis | 16 25·8 | + 7 9 | 1855 | Anderson | *A.* |
| Ophiuchi | 17 49·6 | +11 11 | 1855 | „ | „ |
| | 18 32·8 | +43 50 | 1855 | Williams | „ |
| Scuti | 18 46·3 | −12 47 | 1855 | Ceraski | „ Alg |
| | 18 54·3 | +34 45 | 1855 | Williams | *A.* |
| Lyræ | 19 7·6 | +33 10 | 1855 | Ceraski | „ |
| Cygni | 19 12·2 | +49 55 | 1855 | Anderson | „ |
| | 19 14·4 | +19 25 | 1900 | Schwab | „ Alg |
| „ | 19 28·0 | +28 0 | 1855 | Williams | *A.* |
| | 19 43·3 | +48 49 | 1900 | Hisgen | „ |
| „ | 20 18·0 | +42 46 | 1855 | Williams | „ Alg |
| „ | 20 49·0 | +29 52 | 1855 | „ | *A. N.* |

from the fact that the catalogue proper consists of some 300 closely printed pages, each page having a double column of stars: on the average there may be perhaps eighty stars to a page. The following particulars are given for each star: (1) D.M. number. (2) Position in R.A. and Dec. for 1900. (3) D.M. mag. (4) Photometric mag. (5) Julian dates of observations. (6) Residuals found by subtracting the mean mag. from the individual measures. This catalogue, the result of years of labour on the part of Professor Pickering, must doubtless be of the very greatest value to all workers in variable stars, as well as for statistical purposes in connection with the distribution of stars, generally, in the heavens.

In the annual report of the director of the Harvard College Observatory it is stated that over 16,000 photometric comparisons have been made with the east equatorial; several thousands of observations with the west equatorial. With the 12-inch meridian photometer, 54,448 settings have been made by the director. With the meridian photometer 33,316 settings have been made, bringing the total number with this instrument up to the huge number of 1,033,180. As regards photography, we learn that the 8-inch Draper telescope covers the whole northern sky to S. Dec. 12°·5, from two to four times a year. The Cooke lens covers all the sky visible at Harvard two or more times a month, while the transit photometer furnishes on every clear night a record of all stars crossing the meridian, and visible to the naked eye. Over 28,000 photographs have been taken in all at Arequipa. A further discussion of photographs of variable stars in clusters is in hand.

Dr. S. C. Chandler has announced that owing to pressure of work he is unable to undertake the preparation of a fourth catalogue of variable stars as he had hoped. The Council of the *Astronomische Gesellschaft*, however, are taking up the work, and ask for any unpublished observations which may be of use in determining light-periods to be sent in to them.

Dr. A. W. Roberts, of Lovedale, Cape Colony, has produced (*A. J.* 491–492) an excellent catalogue of southern variable stars, on the lines of Chandler's third catalogue. This is largely the result of his own long-continued observations; and the high character of his work accordingly lends great weight to this catalogue, which includes ninety-four variables, all south of −30° Dec.

The variable star section of the British Astronomical Association has for the past two years been engaged in the systematic observation of a selected number of variable stars, of well-established or popular character. This working list contains forty-six stars embracing the different types of variation. Since 1900 January some 5000 observations have been made on the method of Argelander, and the results published from time to time in the *Journal B. A. A.* Co-operation in the work is the guiding principle, and with this in view the observations are concentrated on the above-mentioned limited number of stars.

Maps of the vicinity of each variable, together with lists of comparison stars and their brightness, have been issued to each observer. In addition, a uniform method of making and recording the observations is adopted. The number of workers is but few; but the results already achieved show how much may be done by co-operation in observation of variable stars. Professor Pickering very liberally furnishes photographs of the vicinity of certain variables as seen in the maps of the D.M. to any regular observers who wish for them. E. E. M.

## *Stellar Spectroscopy in* 1901.

*Spectrum of nebulæ.*—Professor Campbell in his researches on the spectrum of Nova *Persei* has secured photographs of the planetary nebula *N.G.C.* 7027, and in the *Bulletin* No. 8 of the Lick Observatory he gives a reproduction which shows the narrow bright lines with admirable clearness. (Reprint in *Astroph. Jour.* xiv. 269, fig. 12.)

*New stars and stars with peculiar spectra.*—The phenomena presented by Nova *Persei* are dealt with in a separate note, p. 307.

Professor E. C. Pickering refers (*Ast. Nach.* **155**, 124) to the observations obtained of Nova *Aquilæ*, which was discovered in 1899 by Mrs. Fleming on the Draper Memorial photographs. In the later photographs the only lines seen in the spectrum are H$\gamma$ and 5007.

Professor Pickering gives the results of further investigations of the second series of hydrogen lines detected in the spectrum of $\zeta$ *Puppis* (*Ast. Nach.* **155**, 231; *Astroph. Jour.* xiii. 230).

Sir David Gill contributes a note on the spectrum of $\eta$ *Argûs* (*Proc. R. S.* lxviii. 456; and *Monthly Notices*, lxi. App. [66].) It appears that the spectrum closely resembles that of Nova *Aurigæ*.

*Classification of stellar spectra.*—A discussion of the spectra of bright southern stars, which have been photographed at Arequipa with the 13-inch Boyden telescope as part of the Henry Draper Memorial, has been published in the past year. The work has been done by Miss Cannon under the direction of Professor E. C. Pickering; and the memoir forms Part II. of volume 28 of the *Annals of Harvard College Observatory*, Part I. being Miss Maury's discussion of the bright northern stars. The whole volume therefore "furnishes the principal facts regarding the spectra of all the brighter stars from the North to the South Pole;" Part I. dealing with 681 stars north of declination $-30°$, Part II. with 1122, chiefly in the southern hemisphere. The stars dealt with in Part II. are classified arbitrarily, and divided into thirty-one classes, which are designated according to the notation of the Draper Catalogue, modified so that intermediate classes can be indicated.

*Velocity in the line of sight.*—The most notable event in this branch of the subject is the publication of Professor Campbell's "Preliminary determination of the Motion of the Solar System" (*Astroph. Jour.* xiii. 80), based on the radial velocities measured at the Lick Observatory. The 280 stars available for this research were divided into 80 groups by combining neighbouring stars into one group. The following elements of the solar motion were obtained :—

$$\text{Velocity} = -19{\cdot}89 \text{ km/sec} \pm 1{\cdot}52$$
$$\alpha_0 = 277^\circ\ 30' \qquad \pm 4^\circ{\cdot}8$$
$$\delta_0 = +19^\circ\ 58' \qquad \pm 5^\circ{\cdot}9$$

*Stars with large radial velocity.*—Professor Campbell gives (*Astroph. Journ.* xiii. 98) the following examples :—

| | | | |
|---|---|---|---|
| $\epsilon$ *Andromedæ* | −83·7 km/sec. | $\theta$ *Canis Majoris* | +96 km/sec. |
| $\mu$ *Cassiopeiæ* | −97·4 | 1 *Pegasi* | −76 |
| $\delta$ *Leporis* | +95 | $\mu$ *Sagittarii* | −76 |

Groombridge 1830 −95

*Variable radial velocity.*—Six stars with variable radial velocity have to be added to the list given in last year's report.

| | $\alpha$ h m | $\delta$ ° ′ | Discovered. | Reference. |
|---|---|---|---|---|
| $\xi$ Piscium | 1 48 | + 2 42 | Lick Observatory. | Lick Obs. *Bull.* No. 4 (*Astroph. Journ.* xiv. 138). |
| $\xi_1$ Ceti | 2 8 | + 8 23 | „ „ | „ „ |
| $\tau$ Persei* | 2 47 | +52 22 | „ „ | „ „ |
| $\epsilon$ Hydræ | 8 42 | + 6 48 | „ „ | „ „ |
| $\sigma_1$ 31 Cygni* | 20 10 | +46 26 | „ „ | „ „ |
| $\pi$ Cephei | 23 5 | +74 51 | „ „ | „ „ |

* This star occurs in list of stars with composite spectra (*Ann. Harv. Coll. Obs.* xxviii. 93).

*Orbits of spectroscopic binaries.*—Orbits for the following stars have been published :—

| | | |
|---|---|---|
| $\alpha$ Ursæ Minoris | Hartmann | Berlin Akad. Sitzb. 1901, 444<br>*Astroph. Jour.* xiv. 52 |
| $\zeta$ Geminorum | Campbell | „ „ xiii. 90 |
| $\zeta$ Ursæ Majoris (Mizar) | Vogel | Berlin Akad. Sitzb 1901, 534<br>*Astroph Jour.* xiii. 324<br>2nd Paper. Arch. Néerl., Harlem 1901, 661 |
| $\alpha$ Aurigæ | Campbell & Reese | Bull. Lick Obs. No. 6<br>*Astroph Jour.* xiv. 261 |
| $\eta$ Pegasi | Campbell & Crawford | Bull. Lick Obs. No. 5<br>*Astroph. Jour.* xiv. 202 |

*New Instruments.*—Professor Frost describes (*Astroph. Jour.* xv. 1) the new Bruce spectrograph of the Yerkes Observatory, and also the methods adopted in measuring and reducing the photographs. As examples of the results obtained, details are given of a photograph of *a Arietis*, for which a velocity of −13·66 km./sec. is deduced, in good agreement with the results obtained by Campbell −14·1 Vogel and Scheiner - 14·7 and Lord −14·0. Three photographs of *ε Leonis* give velocities +4·4, +3·5, +4·0 km./sec. ; thus the variability previously suspected is not corroborated, and the new results are in complete agreement with Wright's measures at the Lick Observatory.

Dr. J. Hartmann describes (*Zeitsch. f. Inst. Kunde*, xxi. 1901, p. 313) a careful set of observations of the effects of changes of temperature in the Potsdam spectrographs, and gives a description of the method of controlling the temperature of the large spectrograph to be used for the determination of the radial velocity of stars. An automatic arrangement has been adopted for switching the requisite electric currents through wires stretched inside the cover which enclosed the whole spectrograph.

*Reduction of observations.*—Dr. J. Hartmann gives a full account of the procedure adopted at Potsdam in measuring and reducing the photographed spectra of stars (*Ast. Nach.* **155**, 8).

H. F. N.

### *Revision of Taylor's Madras Catalogue for* 1835·0.

The revision of an old catalogue must always be a source of anxiety to the revisor, for the policy of revision and the amount of revision required are inseparably mixed up, and are practically only to be justified by the final results.

Dr. Downing some years ago undertook the superintendence of the work involved in revising the star places of the Madras Catalogue. A succession of grants from the Royal Society has paid for the expense of the calculation, and the cost of publication has been borne partly by the India Office and partly by the Royal Society. It may be a truism to say that the two cardinal principles which underlie the value of such a work are, first and foremost, that the observations themselves and the data on which they depend are of such a character that when reduced on modern principles with modern data they compare favourably with modern results ; and, secondly, that the revision shall be sufficiently thorough to produce the best results from the originals. With reference to the first point, a study of the Madras volumes of observations can only tend to impress the reader with a very high opinion of Mr. Taylor and the enormous difficulties he had to contend with. Occasionally the Observatory was blown down about his ears ; everlastingly the marks on which his azimuth error depended caused him constant trouble.

In *Madras Observations*, vol. ii., p. 42, he says: "On a late occasion I paid a visit to the south mark, which is at the end of a very substantially built brick dwelling-house situated about 1½ mile from the Observatory; here I found a crack in the wall about two inches wide, which is just sufficient to account for the alteration above found; the north mark is a square (brick and chunam) pyramid of weather-beaten and rough exterior, thereby offering no means of detecting a small alteration of the foundation; but from the nature of the soil (a bed of loose sand) it is easy to believe that a considerable fall of rain (such as happened about this date) might have produced the alteration in question."

With reference to the second point, Dr. Downing remarks in his introduction: "The revision of a catalogue of 11,000 stars is a work of such magnitude that it was necessary to exercise the utmost vigilance in order to keep the expenses within reasonable limits, otherwise there would have been a danger of the work being left in an unfinished state. Hence the necessity of utilising, as far as possible, the existing material."

Whether the first or the second principle has been violated there is not sufficient evidence to give an opinion, but that the revised Catalogue is affected by considerable systematic errors is shown by the following comparison with Newcomb's Fundamental Catalogue given by Dr. Downing at the end of the Introduction:—

| Limits of Dec. | $\Delta\alpha$. | $\Delta\delta$. | No. of Stars. |
|---|---|---|---|
| ° ° | s | ″ | |
| +75 to +65 | +·172 | +0·44 | 62 |
| 65 „ 55 | +·069 | +0·69 | 63 |
| 55 „ 45 | +·004 | +0·91 | 62 |
| 45 „ 35 | +·025 | +0·78 | 100 |
| 35 „ 25 | −·011 | +0·51 | 101 |
| 25 „ 15 | −·037 | 00 | 110 |
| 15 „ + 5 | −·064 | −0·05 | 117 |
| + 5 „ − 5 | −·064 | −0·14 | 109 |
| − 5 „ 15 | −·066 | −0·07 | 91 |
| 15 „ 25 | −·106 | +0·34 | 86 |
| 25 „ 35 | −·122 | +0·42 | 52 |
| 35 „ 45 | −·107 | +1·07 | 54 |
| 45 „ 55 | −·099 | +2·22 | 40 |
| 55 „ 65 | −·177 | +1·88 | 41 |
| −65 „ −75 | −·199 | +1·31 | 17 |

A considerable amount of the systematic error can of course be eliminated by application of corrections derived from the above table; and the re-reduction has both lessened the accidental error and eliminated the numerical errors of the original catalogues. W. G. T.

*Latitude Variation.*

s again taken up this subject. In *Astro-* 489, he discusses all the material available anges in the annual elliptical component of d comes to the conclusion that the line of from east to west, or in a direction contrary n its orbit, in a long period of some seventy- rate of about 5° per annum, and the length l oscillates about its mean value with a cycle s.

90 and 494, he again attacks the theory of polar y concludes that it is the resultant of three annual term and two others, whose periods are 5 and 436·0 days, motions circular and radii o. The superpositions of these two periods is cle of something like seventy years. For five- e the changes of period vary between 428·5 and suddenly shorten to minimum 415 days, and gthen. Similarly, the variations of the radius of gularly asymmetrical. Dr. Chandler bases these the discussion of thirty-seven series of observa- from 1726 to 1900, the results of which are ient tables. He also gives a diagram showing at omparison between theory and observation, and servation to prove him wrong in a very few years, s of motion is rapidly approaching its minimum nd the period its minimum length of 415 days.

No. 511, and R.A.S. *Monthly Notices*, lxii. p. 122, he lts of his discussion of the observations made with h reflex zenith tube, and remarks that the instru- accomplished an even higher service to intended, and that in

Bradley come to the discovery of polar motion." And this with only a 2·8-inch object-glass and a few yards of iron tube and wire. W. G. T.

## *Geodesy.*

The *Comptes Rendus* of the thirteenth Conference of the International Geodetic Association, which was held at Paris in 1900, published during the past year, contains a report by Major Burrard of the work of the Indian Trigonometrical Survey. The scheme of this work may be sketched by saying that main lines of triangulation cross the country, east to west, from Calcutta to Karachi, from Vizagapatam to Bombay, and another, north and south, passes through Dehra Dun, Agra, and Kalianpur, so that the country is divided into four quadrilaterals and the South Trigon, each of which is surveyed in detail by minor lines of triangulation. This main survey was finished some years ago, and the work has been extended westward into Persia and eastward into Burmah. Major Burrard refers in his report to this last-mentioned section. The survey of the Burmese peninsula consists at present mainly of a loop of triangulation which was along the western coast to Sandoway, then, turning south-eastward and then northward, passes almost along the meridian 96° east of Greenwich, and the circuit is completed by an east to west chain of triangles through Manipur. This loop is connected to the Indian Survey by two short chains of triangles, and it had been feared that the earthquake in Siam in 1897 must have had results to the serious detriment of this geodetic work. In the report on Indian geodesy made at the previous Conference of the Association in 1898 a fear was expressed that this earthquake might have severed the Indian and Burmese systems of triangulation, but that this could only be proved by the closing of the circuit when the line of triangles through Manipur was completed. Major Burrard reported in 1900 that this line was then finished, and that the re-observation of certain angles showed that no evil effects had been sustained. The closing errors of the great Burmese circuit are worth noting, as they show the degree of accuracy attained by the Indian Survey. The triangulation carried from the junction with the main Survey, southward and round the loop above described, ends in the side of a triangle at Manipur whose length, computed from the chain, is 79,530·40 feet. Its length, computed from the remainder of the loop west of Manipur, is 79,531·22 feet, the discrepancy being only 0·82 foot. The discrepancy in the azimuth of this closing side is 2″·256, and the geodetic position of the closing station as derived from the western chain is 60 feet different from that shown by the eastern observations. In his report to the Conference Major Burrard gave an analysis of the astronomical observations made at stations round Kalianpur to determine the

local attraction, which have since been publish
form,* and have lately formed the subject of a
by him to the Society. The result of these g
the astronomical position of Kalianpur—that
een chosen by Colonel Everest as the origin o
ecause the surface of the ground around it gave n
ion—derived from the latitudes and longitudes
annot be regarded as absolute.

avid Gill's report on the Survey of Rhodesia, some d
have already been mentioned in the *Monthly N*
iscussion at the Conference on the merits of the Ja
suring apparatus, Sir David having mentioned tha
steel wires which are the main feature of this appa
to molecular changes of length.

tion must be called in this note to the determinat
rc of longitude, Potsdam-Bucharest, made by Prof
and Borrass, of the Prussian Geodetic Institute, in
old registering micrometer, fitted to meridian in
the *coudé* type, was used for recording transits. The
crometer is that the observer causes a movable w
contact with the star-image and the time of tra
automatically. Judging from the accordance of r
this determination, the apparatus must certainly be
success. It was expected that the method would dim
nt of the personal equation, and the difference o
between these observers, which had previously
han $0^s{\cdot}10$, became $0^s{\cdot}017$, and at the same tim
or of the result of one night's determination

## Papers read before the Society from March 1901 to January 1902.

1901.

Mar. 8. Observations of the partial eclipse of the Sun, 1900 November 22, made at Perth Observatory, Western Australia. Communicated by W. E. Cooke.

On the observation of position angles of polar double stars. R. T. A. Innes.

On the Oxford photographic determinations of stellar parallax : reply to the criticisms of Sir David Gill. H. H. Turner.

Occultations of *Jupiter* and his satellites, 1900 September 29, observed at Windsor, New South Wales. John Tebbutt.

Cape double star results, 1900. Communicated by Sir David Gill.

Observations of the *Leonids*, 1900 November 15–16, made at the Royal Alfred Observatory, Mauritius. Communicated by T. F. Claxton.

Description of a floating photographic zenith telescope and some preliminary results obtained with it. Bryan Cookson.

Note on Mr. Bryan Cookson's paper, "On the accuracy of eye observations of meteors, and the determination of their radiant points." H. C. Plummer.

The variable star *R Centauri*. Alex. W. Roberts.

On the new star in *Perseus*. A. Stanley Williams.

Further corrections to the Armagh Catalogue ; with special reference to the "Anonymous" stars. J. L. E. Dreyer.

Notes on the spectrum of Nova *Persei* observed at the Stonyhurst College Observatory. Rev. W. Sidgreaves.

Positions of Nova *Persei* and 159 stars within 25′ distance from it ; from a photograph taken at the University Observatory, Oxford. F. A. Bellamy.

Note accompanying photographs of the spectrum of Nova *Persei*. Frank McClean.

Observations of the new star in *Perseus* made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

A first note on the Nova in *Perseus*. K. Naegamvala.
Note on some engraved charts of Pogson's prop Atlas of Variable Stars. Rev. J. G. Hagen.
Meteoric showers from the region of $\alpha$—$\beta$ *Persei* $\eta$ *Aurigæ*. W. F. Denning.
Anomalous occultations of stars by the Moon. R. T Innes.
A method of mechanically compensating the rotatic the field of a siderostat. H. C. Plummer.
Variations of *R Horologii* during 1900. Alex. Roberts.
Note on meridian observations of Nova *Persei*. Graham.
Further observations of the new star in *Perseus*. Stanley Williams.
The spectrum of Nova *Persei*, Note 2. Rev. Sidgreaves.
The spectrum of Nova *Persei*, Note 3; Nova *Pers* a variable star with a variable spectrum. Rev. Sidgreaves.
Observations of Nova *Persei*. M. C. Sharp.
Further measures of double stars made at the Te Observatory, Rugby, during the years 1895 to 1 G. M. Seabroke, H. P. Highton, and E. C. Atkir
Observations of the new star in *Perseus* made at Radcliffe Observatory, Oxford. Communicated

1901.

May 10. Further observations of the new star in *Perseus*, made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Results of micrometer measures of double stars made with the 28-inch refractor of the Royal Observatory, Greenwich, in the year 1900. Communicated by the Astronomer Royal.

Additional note on the position of Nova *Persei*, and a comparison of photographic magnitudes of neighbouring stars with those of Fr. Hagen's Chart and Catalogue. F. A. Bellamy.

Note on the geometry of the siderostat. H. C. Plummer.

June 14. Observations of *Mars* made at Mr. Edward Crossley's Observatory, Bermerside, Halifax, during the opposition of 1900–1901. Joseph Gledhill.

On a modified form of revolving occulter for adapting the exposure of the Sun's corona to its actinic intensity at all distances from the Moon's limb. D. P. Todd.

The Oxford determinations of stellar parallax. Reply to Professor Turner. Sir David Gill.

Light curve of Nova *Persei*, 1901. Laurence Child.

Sun-spots and magnetic disturbance. William Ellis.

Observations of Nova *Persei* made at Birr Castle Observatory, Parsonstown. The Earl of Rosse.

Secular variation in the period of *R Carinæ*. Alex. W. Roberts.

The great Comet of 1901 as observed at the Royal Observatory, Cape of Good Hope. Sir David Gill.

The Oxford photographic determinations of stellar parallax. Further reply to Sir David Gill. H. H. Turner.

Measures of double stars made at Mr. Edward Crossley's Observatory, Bermerside, Halifax. Joseph Gledhill.

Corrections to reduce the revised Madras Catalogue of stars for 1835·0 to the Fundamental Catalogue of Auwers. A. M. W. Downing.

The *Lyrids*, 1901 April, observed at Cambridge. J. C. W. Herschel.

Further observations of the new star in *Perseus* (4). A. Stanley Williams.

Observations of the Sun during 1901 May 17, 18 and 20, at Mells, near Frome. Maures Horner.

Estimations of magnitude of Nova *Aurigæ* in 1899–1900, with the mean results for the years 1892–1900, from observations at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Further observations of the new star in *Perseus* made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Solar eclipse, 1901 May 18 (observations of the p
phase at Perth Observatory, Western Austr
W. E. Cooke.

The normal equations that arise in the usual schen
observation for division errors, and their solut
P. H. Cowell.

Errata in the revised Madras Catalogue of star
1835·0. A. M. W. Downing.

Mean areas and heliographic latitudes of Sun-spo
the year 1900, deduced from photographs take
the Royal Observatory, Greenwich, at Dehra
(India) and in Mauritius. Communicated by
Astronomer Royal.

A new form of reflecting telescope. Charles Antl

The green flash at sunset. W. H. Pickering.

Observations of Comet 1901 I. made at Perth O
vatory, Western Australia. Communicated by W
Cooke.

Note in reply to Mr. Plummer's paper (*Monthly No*
vol. lxi. pp. 368–375). Bryan Cookson.

Recent observations of the position of Nova *Au*
with the 40-inch telescope of the Yerkes Observa
E. E. Barnard.

On the accuracy of photographic measures; bei
discussion of a recent paper by M. Loewy. I
Plummer.

The determination of selenographic positions and

1901.

Nov. 8. Determination of Dr. Küstner's magnitude equation, from comparison of his meridian observations in zones $+24°$ to $+27°$ with measures of photographic plates taken at the University Observatory, Oxford. H. H. Turner.

On the place of the variable *RU Herculis* and neighbouring stars from photographic measures. F. A. Bellamy.

Experimental reduction of some photographs of *Eros* made at the Cambridge Observatory for the determination of the solar parallax. A. R. Hinks.

Further observations of the new star in *Perseus* made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Additional note on the green flash at sunset. W. H. Pickering.

Dec. 13. The observed motion and duration of the radiant point of the *Perseids*. W. F. Dunning.

Observations of Nova *Persei*. J. E. Gore.

Apparent paucity of the *Leonid* stream. Rev. S. J. Johnson.

Contribution to the history of the reflex zenith Tube. S. C. Chandler.

Note on a large fireball. W. F. Denning.

On the accuracy of measures on photographs: remarks on recent papers by M. Loewy and Mr. H. C. Plummer. A. R. Hinks.

On a simple method of accurate surveying with an ordinary camera. H. H. Turner.

The *Leonids*, 1901. Observations made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

The *Leonids*, 1901. F. W. Henkel.

Description of Adams's MSS. on the perturbations of *Uranus*. R. A. Sampson.

On the velocity of $\alpha$ *Persei*. H. F. Newall.

1902.

Jan. 10. Observation of the *Leonid* meteors of 1901 made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

The attraction of the Himalaya Mountains upon the plumb-line in India. Major S. G. Burrard.

Period and light curve of 6685 *Y Lyræ*. A. Stanley Williams.

$\Sigma$ 1639 *Comæ Berenicis*. Thomas Lewis.

Observations of occultations of stars by the Moon and of phenomena of *Jupiter's* satellites made at the Royal Observatory, Greenwich, in the year 1901. Communicated by the Astronomer Royal.

*Papers read before the Society.*

Observations of the satellite of *Neptune* from
graphs taken at the Royal Observatory, Gree
in 1899–1900. Communicated by the Astr
Royal.

On periodic orbits. E. T. Whittaker.

Comparison of photographic and visual magnit
the new star in *Perseus*. W. H. Robinson.

## List of Public Institutions and of Persons who have contributed to the Library, &c., since the last Anniversary.

His Majesty's Government in India.
The Lords Commissioners of the Admiralty.
The French Government.
The Italian Government.
The Norwegian Government.
British Association for the Advancement of Science.
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British Horological Institute.
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eny Observatory.
rdam, Royal Academy of Sciences.
i, Royal Observatory.
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lasian Association for the Advancement of Science.
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y Branch of the Royal Asiatic Society.
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Kiel, Royal Observatory.
Kodaikanal Observatory.
Leiden Observatory.
Leipzig Astronomical Society.
Leipzig, Prince Jablonowski Society.
Leipzig, Royal Society of Sciences of Saxony,
Lick Observatory.
Lund, Astronomical Observatory.
Madison, Washburn Observatory.
Madrid, Royal Academy of Sciences.
Manila Observatory.
Mauritius, Meteorological Society.
Mauritius, Royal Alfred Observatory.
Melbourne, Government Observatory.
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Odessa Observatory.
O-Gyalla, Central Meteorological and Magnetical Observatory.
Ottawa, Scientific and Literary Society.
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phia, University of Pennsylvania.
nperial Hydrographic Office.
eteorological and Magnetical Observatory.
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n, Central International Geodetic Bureau.
n, Royal Prussian Geodetic Institute.
eepsie, Vassar College Observatory.
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## ADDRESS

*President, Dr. J. W. L. Glaisher, on presenting dal of the Society to Professor J. C. Kapteyn.*

the Gold Medal of the Society to Professor J. C. work in connection with the Cape Photographic and his researches on stellar distribution and uncil have been able to place on record at the nity their admiration of the noble services he has ronomy ; and it is now my privilege to give a this great photographic catalogue and to refer to 's other contributions to stellar cosmography.

tried the experiment of photographing the great ar by means of a lens mounted in an ordinary as attached to the counterpoise of an equatorial. sults which he obtained suggested to him that with s photographic star maps could be constructed on le and to any required order of magnitude.

sit to England in the early part of 1884 Gill allmeyer a rapid rectilinear lens of 6 inches aper- ches focus, this being the most suitable lens for

your success in stellar photography, and especially after your letter in which you tell me, 'I am obliged to crave help where I can get it,' it has occurred to me that by measuring and reducing your photographs I could contribute very effectually towards the success of an enormous and eminently useful undertaking. Since then I have revolved the idea in my mind, and I have come to the conclusion that if you will let me, and if I can secure the necessary help, there is no one can be in better conditions to undertake the work than myself." In the concluding paragraph of the same letter, referring to the opinions of those he had consulted, he proceeds: "I am bound to say that they were not very enthusiastic about the matter; of course they thought the results once reached of immense value, but the drudgery to be gone through before these results are got into the form of a catalogue almost unbearable. However, I think my enthusiasm for the matter will be equal to (say) six or seven years of such work." As we shall see, Kapteyn did not overestimate his enthusiasm, which was to sustain him not only for six or seven years, but for nearly thirteen.

The actual photographing of the plates at the Cape, begun in April 1885, was continued without interruption until its completion at the end of 1890. There were several vicissitudes, principally relating to the lens. A second Dallmeyer lens of 6 inches aperture and 69 inches focus, which was expected to be superior to the first, was used for a time but found to be not so satisfactory. The portions of the sky, therefore, which had been photographed by it were rephotographed by the old lens, so that all the plates definitively used in the catalogue should be the work of the same lens.

The principal object which Gill had in view may be briefly described as the extension of the Bonn *Durchmusterung* to the south pole. To determine the exposure necessary for this purpose an area in the Bonn *Durchmusterung* was selected and photographed. The negative was then compared star by star with Argelander's chart, and the duration of the trial exposures was gradually increased till it was certain that every star in the selected part of the chart was shown as a measurable disc on the plate photographed from the sky. It may be mentioned that when the negative from the sky showed nearly the whole of Argelander's stars it also showed a great many more, as the Bonn *Durchmusterung* only professes to be complete as far as stars of the 9·2 magnitude.

Different kinds of plates were used during the five years over which the work extended. At first an exposure of an hour was required, but after about a year and a half more rapid plates were used, and the exposure was greatly reduced. At the time when the work was begun the difficulties were much greater than they would be now; the remarkable difference between the actinic and visual light of stars in different regions was unknown, as also was the variation of the sensibility of the plates due to moonlight

and other causes. Every area was photographed on two different nights in order to avoid the possibility of a speck on the plate being mistaken for a star.

I pass now to Kapteyn's work at Groningen : the measurements of the stars on the plates, their reductions, and the formation of the catalogue.

All the measurements for the catalogue were made by an instrument designed by Kapteyn for the purpose. The principle of this instrument, the object of which was to measure spherical coordinates directly from the plate, occurred to him very soon after he had received the first plates ; it depends upon the obvious fact that by placing a plate at the proper distance (that is, at the focal distance of the photographic telescope), with the film farthest from the eye, it is possible to cover the stars in the sky with their corresponding images. If, therefore, we substitute for the eye an instrument by which spherical coordinates can be measured in the sky, we can measure these coordinates as well on the plate as in the sky.

This instrument was employed in the early part of 1887 to measure the circumpolar plates (which were those first taken) to the tenth of a minute of arc, and it was found to be rapid and convenient in use and to give results of the accuracy required for a *Durchmusterung*. It was also shown that the stellar images were sufficiently sharp to be easily measurable to a second of arc, and a parallactic instrument capable of giving results to this degree of accuracy was devised by Kapteyn and Gill. It was, however, not constructed, and the whole of the measurements were made, to the tenth of a minute of arc, by the same instrument by which the circumpolar plates had been measured. In using this instrument Kapteyn always fixed two plates, corresponding to the same portion of the sky, in the plateholder, one in front of the other, at the distance of a millimetre. Small motions were provided, by means of which the corresponding star images of the two negatives could be brought nearly, but not quite, to superposition, so as to appear in the telescope like double stars, and thus true star images were at once distinguishable from accidental specks on the plates. Of these two plates, in case of the slightest difference, the one on which the images were more dense was employed to act as the check plate ; the other, mounted in front, was used as the measuring plate. The observations were made in a darkened room, the plates being illuminated from behind by a powerful lamp. The plates were square with a side of about six degrees.

In measuring the plates two observers always worked together, one at the ocular, one at the microscope of the hour circle. A clerk wrote down all the numbers called out by the two observers in ledgers prepared for the purpose. The observer at the ocular estimated the diameter, read off the declinations on the scale, and made the pointings for right ascension. These were read off by the observer at the microscope. Three or four

hours in the morning and three hours in the evening were generally devoted to the observations.

Every plate was observed twice, the two observations being quite independent. As soon as the second observation of a plate was completed the two observations were compared and the discrepancies examined. The second observations and the examinations and revisions were invariably made by Kapteyn himself.

The diameters of the images of the stars were estimated to tenths of a minute of arc. This unit, however, being found too large in practice was subdivided into thirds. From these diameters the magnitudes of the stars were determined by an empirical formula involving two constants, which will be referred to later.

Great pains were taken that no speck on the plates should be treated as a star; so careful indeed was Kapteyn in this matter that, as he states himself, many thousands of objects, by far the greater part of which are certainly true stars, have been lost to the catalogue. But it was his settled policy from the beginning not to introduce any object that was not a true star, and rather to lose ten real stars (of the very faintest class) than to incur the danger of introducing a single fictitious one.

Having now described in general terms the manner in which the plates were taken at the Cape, and observed and reduced at Groningen, I have to speak of certain special difficulties under which the work was carried out. As already mentioned a grant from the Government Grant Fund was made in 1885. The grant was repeated in 1886, but not in 1887. In that year the International Astrophotographic Congress had decided to undertake the work of forming a catalogue of stars to the 11th magnitude, and making charts of the heavens approximately to the 14th magnitude. It may have been thought by some that Gill's project was superseded by the decision of the Congress, but he himself never doubted the desirability of his own work, believing that in the existing state of astronomy its urgent need was increased rather than diminished by the results of the Congress. The completion of the work, however, without external assistance taxed even Gill's energy and resourcefulness to the utmost. Fortunately he persisted to the end; but he was unable to have the parallactic instrument constructed that would have measured the plates to a second of arc, and he did not carry the work north of the declination $-18°$.

Kapteyn obtained some assistance from the Dutch Government and from several Dutch institutions, which enabled him to retain the services of two and sometimes three assistants. Only one, however, remained with him throughout; the others, who were all at first quite inexperienced in work of the kind, frequently left after a short time, and these frequent changes added to the difficulties, and delayed the progress, of the work.

At length the catalogue was completed and published, forming three volumes of the Annals of the Cape Observatory. The

ars the date 1896, the second 1897, the third 1900.
includes all stars down to about the 9·5 magnitude
the south pole. It has been mentioned that Gill's
extend Argelander's *Durchmusterung*, which was
he middle of the last century, to the south pole,
gnitudes and approximate positions of the stars.
work, which included stars to the 9th or 10th
ntained 324,188 stars; Schönfeld, who continued
rom $-2°$ to $-23°$, included 133,659 stars between
The Cape *Durchmusterung* contains 454,875 stars
and the south pole.

gues of Argelander and Schönfeld contain 431,760
est of the sky. The average number of stars for
legree in the Cape, Argelander, and Schönfeld
32·66, 15·19, and 18·21 respectively, so that the
the Cape catalogue is more than double as great
der's catalogue. The latter catalogue set a good
gards freedom from errors, and there is every
ve that Kapteyn has fully maintained this high
e present volumes.

ult to speak in too high terms of the zeal and
ed by Kapteyn during the years that he devoted to
In the preface to the third and last volume
him in the following terms: "It is my colleague
ose name appears on the title page, to whom I am
est obligation. At a time of great stress and dis-
e lifted from my shoulders a load of responsibility
nd spontaneous offer to undertake the measure-

Indeed we do appreciate his spirit and his work; and we are delighted to have the means of expressing our appreciation as a Society to Kapteyn in person here to-day. Sustained by his enthusiasm for the value of the work, he did not shrink from carrying out himself the monotonous and anxious labour of making the measurements and comparisons, so that the catalogue has the great advantage of being the work of a single mind, incessantly devoted to securing the best results that the data could afford. If the enormous amount of work required by the measurements may, perhaps, be described—as it was by Kapteyn's friends at the outset—as drudgery, it was quite otherwise with the methods of procedure, many of the questions to be dealt with being novel and full of interest, as this was the first photographic catalogue. The most important of these questions related to magnitude, and it fell to Kapteyn to have to investigate in much detail the relation between photographic and visual magnitudes.

By comparing the variation of star-density as determined from the plates with the variation as determined by the visual observations of Schönfeld and Gould, he found that in some regions the plates contained three times the number of stars given by Schönfeld in the same area, while in other regions Schönfeld's catalogue was the richer, containing almost double the number of stars shown on the plates. He also found that, corresponding to these variations in the numbers of stars, there were similar variations in their brightness, equal diameters on the plates being produced by stars of very unequal brightness, in different parts of the sky. It is possible, as suggested by Thome, that the cause of these variations is purely observational, the visual observer not including so many very faint stars in the richer, as in the poorer, regions of the sky; but Kapteyn considers any such explanation quite inadequate, and concludes definitely that the difference between the visual and photographic magnitudes is largely dependent upon the position of the stars relative to the Milky Way, and that, even when we take into account only stars of one and the same spectral type, those in the Milky Way are in general bluer than the stars in other regions of the sky.

The magnitudes were deduced from the diameters by the empirical formula $m = \frac{B}{d} + C$, $d$ being the diameter of the image and B and C constants which were determined for each plate by comparing a number of stars with the magnitudes in Schönfeld's catalogue or in Gould's zone catalogue. This formula gives good results for stars between the magnitudes 6·5 and 9·5, but the uncertainty increases rapidly beyond these limits. The same formula has been used for the whole catalogue, the values of B and C being given for each plate, so that it will be easy to make the necessary corrections when a better formula is known or even to fall back, if need be, upon the quantities

ed—that is, on the diameters of the stars on the

ect to the limits of magnitude to which the catalogue
lered complete, Kapteyn concludes that the whole
omplete to stars of the photographic magnitude
it will be found practically complete in or near the
o stars which in the scales of Gould, Schönfeld, and
the magnitude 9·5, and for the rest of the sky to
ly equivalent to these.

alogue itself it is noted when a star is suspected of
or variable, or nebulous, and references are given
ipal catalogues in which a star has previously
characteristic feature of the work is the extreme
tail of the introductions, which, in addition to
at can render the catalogue more serviceable, con-
ılts of extensive comparisons with catalogues of
ch, for example, as lists of stars of the magnitude
er, not found in the plates. Since the publi-
catalogue Kapteyn has been occupied with the
lists of errors in the other catalogues, lists of stars
roper motions, and of variables, as also with an
of the colours of the stars in the Milky Way.
gations are practically complete. I may mention
y such comparisons that the star with greatest
motion (8″·70) was discovered.

o the enthusiasm and perseverance of Gill and
are now in possession of the Cape *Durchmusterung*.
the fulness of time it will be superseded by the

opinion that it can hardly be supposed that any object photographically brighter than the 9·5 magnitude has failed to be included. From a comparison with Thome's Cordoba catalogue he concludes that the limiting magnitudes of the different plates are in reality more nearly uniform than they were taken to be (in order to represent correctly both the brighter and fainter stars), and that it may be regarded as a fairly complete representation of the southern sky to a photographic magnitude of probably 10·0. This discussion of Newcomb's shows how greatly stellar research has been facilitated by the clearness and fulness with which the data of the catalogue have been presented.

At the time when Kapteyn made his proposal to Gill in 1885 he was occupied at Leyden with the determination of stellar parallaxes. His observations related to 45 stars, and he obtained 15 parallaxes, four of which had been previously determined by other observers. He employed a transit instrument and chronograph, and came to the conclusion that by his method he could obtain results comparable to those given by the heliometer. He suggested a plan for determining the parallaxes of all stars to the 5th magnitude. Each star was to be compared with two stars of the 8th magnitude. The whole scheme involved 16,640 complete observations, which he calculated could be carried out by two observers in eight years.

In 1889 Kapteyn proposed a much more comprehensive scheme—viz. that each plate for the astrographic catalogue should be exposed at three successive epochs of maximum parallactic displacement, being carefully preserved in the intervals of six months and developed after the third series of exposures. The plates would then furnish, in addition to the position of the stars, a first determination of their parallaxes. The proposal was not adopted for the catalogue work, but Professor Donner undertook to obtain with the astrographic equatorial at Helsingfors a series of plates for a definitive trial of this method of obtaining parallaxes *en bloc*. These plates Kapteyn measured at Groningen, and he obtained from them a first determination of the parallaxes of 246 stars. After giving a careful and detailed investigation of the results, he considers the possibility of a general *Durchmusterung* for parallax to include all stars down to the 10th magnitude, about 800,000 in number. This, he thinks, would secure about 500 well-determined parallaxes. Kapteyn's project breaks new ground and raises many questions; his own discussion, however, greatly narrows the issues for those who follow him upon these lines.

There is a great deal of other work connected with stellar parallaxes and proper motions upon which Kapteyn has been engaged, much of which still remains unpublished. As the direct determination of stellar parallax has not as yet given results on anything like the scale required for the purpose of judging of the relative distances of the stars, we are compelled to resort to the parallactic displacement caused by the motion of the solar

ce. This parallactic motion, however, cannot be
n the real proper motion for individual stars, but
reason to think that the real proper motion shows
eference for determinate directions, and it may
ssumed that, in the mean results obtained from
f stars, these real proper motions will destroy each
only that part which is due to solar motion, and
allactic displacement that gives the most reliable
e mean distance of the stars under consideration.
nsform the proper motions from right ascension
on to motions in the apical direction (*i.e.* along
cle joining the star to the solar apex) and per-
it, it is clear that the former is affected by the
tion, but that the cross motion, perpendicular to
rection, gives the true component of the motion
Led by these considerations Kapteyn undertook
resolving in the apical direction and perpendi-
he proper motions of the 2357 stars in Draper's
spectra, which are also included in the Bradley-
gue, and were observed both in right ascension and
The stars were taken from Draper's catalogue
eyn had decided to divide them into groups accord-
pectral type, and to consider the groups separately.
has shown that stars with small proper motions
lly to the first type, and those with large proper
e second. It may be that the stars of the second
ng faster than those of the first, but it seems more
they are less distant. This gives some support to

It will have been seen that one spirit runs through all Kapteyn's work, viz. an effort to treat the great cosmical problems comprehensively, and to apply to them general methods which, though not exact, may be expected to give information which would be quite unattainable by any procedure resting upon an absolutely sure foundation with respect to every individual star. Always occupied with the most effective means of attacking the great problems of the universe, he has never flinched from the heavy labour required to carry his ideas into practice; and it is very fitting that one whose mind has been from the first so much attracted by the more difficult questions presented by the statistics of the heavens should himself have contributed such invaluable material for the study of the subject which he has so much at heart.

*The President then, delivering the medal to Professor Kapteyn, addressed him in the following terms:—*

Professor Kapteyn, in placing in your hands this Gold Medal I wish specially to congratulate you upon the completion of the Cape *Durchmusterung*, and to express to you the hope that your life may long be spared, and that you may have health and strength to extract from this grand storehouse of your own formation many more of the great cosmical truths which it implicitly contains, and to enrich still further by your labours the important branch of our science to which you have devoted your life.

*In handing to Dr. T. D. Anderson the Jackson-Gwilt medal the President addressed him as follows:—*

Dr. Anderson, it is a great pleasure to me to hand you on behalf of the Society the Jackson-Gwilt medal in recognition of your discovery of both Nova *Aurigæ* and Nova *Persei*. Nova *Aurigæ* was discovered by you on February 1, 1892, when of the 4th magnitude, and but for your discovery it might have escaped observation. Nova *Persei* was discovered on February 22 of last year at 2.40 A.M., when of the 2·7 magnitude and low down in the sky. This early discovery of yours made it possible for Pickering to obtain its spectrum before its maximum was reached.

It is no small matter to have discovered one of these Novæ, but it is a veritable *tour de force*, such as *à priori* would have seemed almost incredible, to have discovered both, and I am delighted that we have the opportunity to congratulate you on your success and do honour to your astronomical zeal and intimate knowledge of the sky. Between your two discoveries several new stars had been found at Harvard, but all by photography.

I ought, perhaps, to refer at greater length to the number of variable stars—no less than thirty-eight—that you have discovered; but on the present occasion I should prefer to restrict myself to the subject of the award, your wonderful discoveries of the two great Novæ of our time.

The meeting then proceeded to the election of Officers and Council for the ensuing year, when the following Fellows were elected :—

*President.*

J. W. L. Glaisher, Esq., M.A., Sc.D., F.R.S.

*Vice-Presidents.*

Sir William Abney, K.C.B., R.E., D.C.L., F.R.S.
W. H. M. Christie, Esq., C.B., M.A., F.R.S., Astronomer Royal.
E. B. Knobel, Esq.
H. F. Newall, Esq., M.A.

*Treasurer.*

W. H. Maw, Esq.

*Secretaries.*

F. W. Dyson, Esq., M.A., F.R.S.
E. T. Whittaker, Esq., M.A.

*Foreign Secretary.*

Sir William Huggins, K.C.B., LL.D., D.C.L., P.R.S.

*Council.*

Sir R. S. Ball, M.A., LL.D., F.R.S., Lowndean Professor of Astronomy and Geometry, Cambridge.
A. A. Common, Esq., LL.D., F.R.S.
A. M. W. Downing, Esq., M.A., D.Sc. F.R.S., Superintendent of the *Nautical Almanac*.
Major E. H. Hills, R.E.
Thomas Lewis, Esq.
Frank McClean, Esq., M.A., LL.D., F.R.S.
Major P. A. MacMahon, D.Sc., F.R.S.
A. A. Rambaut, Esq., D.Sc., F.R.S., Radcliffe Observer.
G. M. Seabroke, Esq.
E. J. Spitta, Esq.
W. G. Thackeray, Esq.
H. H. Turner, Esq., D.Sc., F.R.S., Savilian Professor of Astronomy, Oxford.

# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. LXII. MARCH 14, 1902. No. 5


Dr. J. W. GLAISHER, M.A., F.R.S., President, in the Chair.

John Walter Lawrence Child, Vernham, Merton Hall Road, Wimbledon;
José Comas Solá, S. Felipe, 29 S. Gervasio, Barcelona, Spain;
Rev. John Horsley Haslam, M.A., Vicar of St. Saviour's, Denmark Park, S.E.;
Joseph Lunt, B.Sc., F.I.C., Royal Observatory, Cape of Good Hope; and
Joges Chandra Ray, M.A., Professor of Physical Science, Cuttack, Bengal, India,

were balloted for and duly elected Fellows of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Alexander Eugen Conrady, F.R.M.S., 104 Park Street, Camden Town, N.W. (proposed by Edmund J. Spitta);
Henry Tresawna Gerrans, M.A., Fellow and Tutor of Worcester College, Oxford (proposed by Arthur R. Rambaut); and
Maurice Edmond Joseph Gheury, 23 Downshire Hill, Hampstead, N.W. (proposed by Silvanus P. Thompson).

red and ten presents were announced as having since the last meeting, including, amongst others :— s, Mittlere Örter von 570 Sternen aus den auf der reenwich unter Direction von Pond in den Jahren gestellten Beobachtungen abgeleitet (presented by Professional papers of the Survey of India Depart- containing Major S. G. Burrard's paper on the the Himalaya Mountains (presented by the Survey

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*Orbits in the Restricted Problem of Three Bodies.*
By E. T. Whittaker, M.A.

*uction.*—In a paper published in the *Monthly* xii. pp. 186–193, two properties of periodic orbits icated. The periodic orbits discussed in that paper d curves which can be described by a body moving uence of any number of centres of force. It was these centres of force are fixed, so that the energy can be partitioned into kinetic energy, which is a quadratic function of the components of velocity, energy, which does not involve the components of e time at all.

ation of periodic orbits, which is most important onomical point of view, is the application to the

obtained which are analogous to, though differing from, those given in the previous paper.

2. *Formation of the equation of Least Action.*—Of the attracting bodies let S be of mass $m_1$, and J of mass $m_2$. Let O be their centre of gravity, which we can regard as fixed. Let $x$ and $y$ be the co-ordinates of P, when the point O is taken as origin, with the moving line OJ as axis of $x$, and a line perpendicular to it as axis of $y$. Let $x$ be the angular velocity of OJ, and let

$$F(x, y) = \frac{m_1}{SP} + \frac{m_2}{JP}.$$

Then the differential equations of motion of the problem are

$$\begin{cases} \frac{d}{dt}\left(\frac{\partial L}{\partial \dot{x}}\right) - \frac{\partial L}{\partial x} = 0 \\ \frac{d}{dt}\left(\frac{\partial L}{\partial \dot{y}}\right) - \frac{\partial L}{\partial y} = 0, \end{cases}$$

where the Lagrangian function L is given by the equation

$$L = \tfrac{1}{2}\{(\dot{x} - ny)^2 + (\dot{y} + nx)^2\} + F(x, y),$$

and $\dot{x}$, $\dot{y}$ denote $\frac{dx}{dt}$, $\frac{dy}{dt}$ respectively.

The corresponding integral of energy is

$$\tfrac{1}{2}(\dot{x}^2 + \dot{y}^2) - \frac{n^2}{2}(x^2 + y^2) - F(x, y) = h,$$

where $h$ is the constant of energy.

Now write,

$$y' = \frac{dy}{dx} = \frac{\dot{y}}{\dot{x}},$$

and write

$$\Omega = \tfrac{1}{2}\{(\dot{x} - ny)^2 + (y'\dot{x} + nx)^2\} + F(x, y),$$

so that it is equal to L, but is expressed differently,

Now the integral of energy can be written

$$\dot{x}\frac{\partial \Omega}{\partial \dot{x}} - \Omega = h,$$

and this equation can be regarded as giving $\dot{x}$ in terms of $x$, $y$, $y'$, and $h$. Differentiating it on this supposition, we have

$$\dot{x}\frac{\partial^2 \Omega}{\partial \dot{x}^2}\frac{\partial \dot{x}}{\partial y'} + \dot{x}\frac{\partial^2 \Omega}{\partial \dot{x}\partial y'} - \frac{\partial \Omega}{\partial y'} = 0$$

and

$$\dot{x}\frac{\partial^2 \Omega}{\partial \dot{x}^2}\frac{\partial \dot{x}}{\partial y} + \dot{x}\frac{\partial^2 \Omega}{\partial \dot{x}\partial y} - \frac{\partial \Omega}{\partial y} = 0.$$

$= \frac{\partial \Omega}{\partial \dot{x}}$, where L′ is supposed expressed in terms
, so that

$- y) + (1 + y'^2)^{\frac{1}{2}} \{n^2 (x^2 + y^2) + 2F(x, y) + 2h\}^{\frac{1}{2}}.$

last equations become

$$\dot{x} \frac{\partial L'}{\partial y'} - \frac{\partial \Omega}{\partial y'} = 0$$

$$\dot{x} \frac{\partial L'}{\partial y} - \frac{\partial \Omega}{\partial y} = 0,$$

$$\frac{\partial L'}{\partial y'} = \frac{\partial L}{\partial \dot{y}}$$

$$\frac{\partial L'}{\partial y} = \frac{1}{\dot{x}} \frac{\partial L}{\partial y}.$$

on

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{y}}\right) - \frac{\partial L}{\partial y} = 0$$

fore

$$\frac{d}{dx}\left(\frac{\partial L'}{\partial y'}\right) - \frac{\partial L'}{\partial y} = 0,$$

when the integration is taken round the curve C, and if $I+\delta I$ denote the value of the same integral when the integration is taken round the curve C′ (so that the symbol $\delta$ denotes an increment obtained in passing from C to C′), we find, by a method similar to that used in the previous paper, that

$$\delta I = \int \delta p \, . \, K \, . \, \{(dx)^2+(dy)^2\}^{\frac{1}{2}},$$

where, writing

$$\{h+F(x, y)+\tfrac{1}{2}n^2(x^2+y^2)\}^{\frac{1}{2}} = G(x, y),$$

we have

$$K = \frac{G(x,y)}{\varphi} + \cos\phi \frac{\partial G(x,y)}{\partial x} + \sin\phi \frac{\partial G(x,y)}{\partial y} + \frac{n}{\sqrt{2}}.$$

This equation shows that if the quantity K is positive at all points of $C$, then $\delta I$ is positive, and, so the quantity I has its value increased when any curve surrounding $C$ and adjacent to $C$ is taken instead of C as the path of integration.

Now, suppose that another simple closed curve D can be drawn enclosing $C$, and such that at all points of D the quantity K is negative. Then in the same way it can be shown that the quantity I is increased when any simple closed curve D′, enclosed by D and adjacent to D, is taken instead of D as the path of integration.

It follows, therefore, by reasoning similar to that used in the previous paper, that, among the aggregate of simple closed curves situated in the ring-shaped space bounded by C and D, there exists a curve L, for which the value of the integral I is greater than for all the other curves of the aggregate. The curve L thus furnishes a stationary value of the integral of least action, and so is an orbit in the restricted problem of three bodies. We thus obtain theorem

*If one closed curve be enclosed by another closed curve, and if the quantity* K *be positive at all points of the inner curve and negative at all points of the outer curve, then in the ring-shaped space between the two curves there exists a periodic orbit of the restricted problem of three bodies, having the given arbitrary constant h as its constant of energy.*

As the quantity K can be immediately calculated for every point on any given curve, this result furnishes a means of detecting the presence of periodic orbits. It may be regarded as analogous to those methods of finding the position of roots of an algebraic equation, which depend on considerations relating to the sign of some expressions connected with the equation.

4. *An integral connected with the periodic orbits.*—Consider now the integral

$$\frac{1}{2\pi}\iint\left[\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\log\{h+F(x, y)+\tfrac{1}{2}n^2(x^2+y^2)\}\right] dxdy,$$

gration is taken over the interior of any periodic
e restricted problem of three bodies. As the
inite at the points $S$ and $J$ we shall first suppose
are in the interior of the orbit, small circles $\gamma$ and
ound them. If $S$ and $J$ are not enclosed by the
he circles $\gamma$ and $\gamma'$ will be non-existent; but in
the greatest generality we shall assume that they

lenote the region which is contained within C but
and $\gamma'$, we have (by Green's theorem on the con-
rals taken over an area into integrals taken round
f the area) the equality

$$+\frac{\partial^2}{\partial y^2}\Big) \log \{h+\mathrm{F}(x, y)+\tfrac{1}{2}n^2(x^2+y^2)\}\Big] dxdy$$

$$\Big[\Big] \begin{vmatrix} dy \dfrac{\partial}{\partial x} \log \{h+\mathrm{F}(x, y)+\tfrac{1}{2}n^2(x^2+y^2)\} \\ -dx \dfrac{\partial}{\partial y} \log \{h+\mathrm{F}(x, y)+\tfrac{1}{2}n^2(x^2+y^2)\} \end{vmatrix}$$

ound $\gamma$ and $\gamma'$ being inserted only when $\gamma$ and $\gamma'$

gral previously denoted by $\delta$I must be zero when
is taken along an arc of an actual orbit; and
uantity $\delta q$ which occurs in $\delta$I is arbitrary) shows

is satisfied at every point of the curve C. We have therefore

$$\frac{1}{2\pi}\int_C \left(dy\frac{\partial}{\partial x}-dx\frac{\partial}{\partial y}\right)\log\{h+F(x,y)+\tfrac{1}{2}n^2(x^2+y^2)\}$$

$$=-\frac{1}{2\pi}\int_C (2d\phi+2ndt)$$

$$=-2-\frac{\Gamma}{\pi},$$

where $\Gamma$ is the angle through which the whole system of S, J, and P has turned in space during one period of the periodic orbit.

We have next to consider the integrals which arise from the curves $\gamma$ and $\gamma'$. We shall take first the integral arising from the curve $\gamma$. We shall suppose that the centre of $\gamma$ is at S, and that its radius is a small quantity $f$.

Then in the neighbourhood of S we have

$$h+F(x,y)+\frac{n^2}{2}(x^2+y^2)=\frac{m_1}{SP}+\text{terms finite in the neighbourhood;}$$

thus
$$\left(dy\frac{\partial}{\partial x}-dx\frac{\partial}{\partial y}\right)\log\left\{h+F(x,y)+\frac{n^2}{2}(x^2+y^2)\right\}$$
$$=-dy\frac{OS+x}{SP^2}+dx\,.\,\frac{y}{SP^2}+\text{less important terms.}$$

Therefore

$$-\frac{1}{2\pi}\int_\gamma \left(dy\frac{\partial}{\partial x}-dx\frac{\partial}{\partial y}\right)\log\left\{h+F(x,y)+\frac{n^2}{2}(x^2+y^2)\right\}$$
$$=\frac{1}{2\pi\rho^2}\int_\gamma\{(OS+x)dy-ydx\}+\text{infinitesimal terms}$$
$$=\frac{1}{2\pi\rho^2}\times\text{twice the area of }\gamma$$
$$=1.$$

Similarly the integral arising from $\gamma'$ has the value unity.

This result is clearly independent of the radius of the small circles $\gamma$ and $\gamma'$, provided these are infinitesimal; we are thus entitled to speak of the integral of the quantity

$$\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\log\left\{h+F(x,y)+\frac{n^2}{2}(x^2+y^2)\right\}$$

taken over the interior of the periodic orbit, since the arbitrary

ce in the circles $\gamma$ and $\gamma'$ does not affect the value.
We thus obtain the result—

$$\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\log\{h+\mathrm{F}(x,y)+\tfrac{1}{2}n^2(x^2+y^2)\}\,dxdy,$$

*ration is taken over the interior of any periodic ricted problem of three bodies, has the value*

$$-\frac{\Gamma}{\pi},\ \text{or}\ -1-\frac{\Gamma}{\pi},\ \text{or}\ -2-\frac{\Gamma}{\pi},$$

*e periodic orbit encloses both, one, or none of the ; where* $\Gamma$ *is the angle through which the whole l of* S, J, *and* P *turns in space during one period rbit.*

24.

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*es formed by a Parabolic Mirror. First Paper: metrical Theory.* By H. C. Plummer, M.A.

*tion.*—As is well known the staple work of the servatory at Oxford during the past few years has tion of its share of the Astrographic Chart. At

No. 435, simultaneously with one by Mr. J. M. Schaeberle. Previously, in 1887, the subject had been discussed by General Tennant (*Monthly Notices*, vol. xlvii. p. 244). A fourth paper, by Mr. C. W. Crockett (*Astrophysical Journal*, vol. vii. p. 362), will also receive notice. Curiously enough the first two and the last of these papers all bear the date 1898 March. Differences of notation and variety of method have made it necessary to collate these papers with considerable care. The outcome of the examination may be briefly indicated here. In General Tennant's paper an unfortunate slip is pointed out which seems to have escaped detection hitherto, and which makes his final results only an approximation to the truth. I have found that Mr. Schaeberle's formulæ are right, though left in a rather inconvenient form, if we correct an apparent misprint. On the other hand his figures of the image formed by different zones of the mirror are certainly incorrect in detail. In Mr. Crockett's results, so far as they go, there is nothing calling for criticism; on the contrary, I have found his curves, evidently drawn with great care, most interesting. In my own paper rigorous expressions were found for the equations of the reflected ray. The further development of the theory was based on a clearly defined approximation which led in a remarkably simple manner to results sufficiently in accord with the actual appearance of star images. The degree of approximation adopted is easily examined, but no examination was made before and the omission will be rectified in the present paper. The analysis will also be extended so as to consider the form of the image in a plane close to, but not coincident with, the focal plane, a step which has not hitherto been taken in any paper, so far as I am aware.

3. *General Theory.*—I retain as far as possible the notation of my previous paper. Let the equation of the surface of the mirror be

$$4fx = y^2 + z^2 = r^2.$$

Let the plane ZOX be the principal plane, *i.e.* the plane containing the axis of the mirror and the ray incident at O, the vertex, and let $\theta$ be the angular distance of the star from the centre of the field, being in the positive direction from OX. The direction cosines of the normal at P, the point of incidence $(x, y, z)$, are

$$\frac{2f}{\sqrt{4f^2+r^2}}, \quad \frac{-y}{\sqrt{4f^2+r^2}}, \quad \frac{-z}{\sqrt{4f^2+r^2}}.$$

We may then put

$$r = 2f \tan \tfrac{1}{2}v, \; y = r \sin \phi, \; z = r \cos \phi.$$

If F is the focus, $v$ is the angle OFP and $\phi$ is the angle

lanes POX and ZOX. The direction cosines of
ome

$$\cos \tfrac{1}{2}v, \quad -\sin \tfrac{1}{2}v \sin \phi, \quad -\sin \tfrac{1}{2}v \cos \phi.$$

gle between the incident ray and the normal we

$$\cos \chi = \cos \tfrac{1}{2}v \cos \theta - \sin \tfrac{1}{2}v \cos \phi \sin \theta$$

the direction cosines of the reflected ray. Now
sines of the incident and reflected rays may also
the coordinates of points at unit distance from
arallel to those rays. And the direction cosines
ultiplied by $\cos \chi$ are the coordinates of a point
s $\chi$ from O along a line parallel to the normal.
s clearly midway between the other two, and by
fact we obtain

$$\begin{aligned}
&\cos \tfrac{1}{2}v \left[\cos \tfrac{1}{2}v \cos \theta - \sin \tfrac{1}{2}v \cos \phi \sin \theta\right] \\
&-2 \sin \tfrac{1}{2}v \sin \phi \left[\cos \tfrac{1}{2}v \cos \theta - \sin \tfrac{1}{2}v \cos \phi \sin \theta\right] \\
&-2 \sin \tfrac{1}{2}v \cos \phi \left[\cos \tfrac{1}{2}v \cos \theta - \sin \tfrac{1}{2}v \cos \phi \sin \theta\right].
\end{aligned}$$

$$\left.\begin{aligned}
&-\sin v \sin \theta \cos \phi \\
&\theta \sin \phi + \sin^2 \tfrac{1}{2}v \sin \theta \sin 2\phi \\
&\theta \cos \phi + \sin^2 \tfrac{1}{2}v \sin \theta \cos 2\phi - \cos^2 \tfrac{1}{2}v \sin \theta
\end{aligned}\right\} \quad (1)$$

the reflected ray, whose direction cosines have

These simple expressions make a very convenient basis for a study of the aberration in the focal plane of a parabolic mirror.

5. Let us now put

$$d = -f \tan\theta \sec v, \quad a = \tan^2 \tfrac{1}{2}v, \quad b = \tan v \tan\theta.$$

Then the equations found for the co-ordinates may be written

$$\left.\begin{aligned} \frac{\eta}{d} &= \frac{a \sin 2\phi}{1 - b\cos\phi} \\ \frac{\zeta}{d} &= \frac{1 + a\cos 2\phi}{1 - b\cos\varphi} \end{aligned}\right\} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

and these may be regarded as equations in terms of a third variable $\phi$ of the geometrical image formed in the focal plane by a circular zone of the mirror. They are in the form most convenient for the discussion of the properties of the curve which they represent, and make it easy to plot the curve for any assigned values of the constants. It is merely of mathematical interest to eliminate $\phi$ and so obtain the ordinary Cartesian equation. It is convenient first to move the origin from the centre of the field along the axis of $\zeta$ to the point $\zeta = d(1-a)$. When this is done the result of elimination is :

$$\begin{aligned} &(\eta^2+\zeta^2)[\eta^2\{(1-a)b^2+2a\}^2+4a^2(1-b^2)\zeta^2] \\ &\quad + 2d\zeta[\eta^2\{b^2(1-a)^2(b^2\overline{1-a}+2a)+2aJ\} - 4a^2\zeta^2(b^2\overline{1-a}+2a)] \\ &\quad + d^2J\{b^2(1-a)^2\eta^2 - 4a^2\zeta^2\} = 0 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4) \end{aligned}$$

where

$$J = b^2(1-a)^2 - 4a^2.$$

The curve is therefore a quartic.

6. We can now draw from (2) some simple inferences with regard to the properties of the curves formed by the rays reflected at a circular ring of the mirror. In the first place we see, by changing the sign of $\phi$, that the curve is symmetrical about a radius through the centre of the field, a fact which is obvious *a priori* and from the form of equation (4). On the trace of the principal plane or axis of symmetry we have the following scheme of values :—

$$\phi = 0, \quad \eta = 0, \quad \zeta = -f\frac{\tan\theta \cdot \sec v \sec^2\frac{1}{2}v}{1 - \tan v \tan\theta} = d \cdot \frac{1+a}{1-b} \ldots \quad (A)$$

$$\phi = \frac{\pi}{2}, \quad \eta = 0, \quad \zeta = -f\tan\theta \cdot \sec^2\tfrac{1}{2}v = d(1-a) \quad \ldots \quad (B)$$

$$\phi = \pi, \quad \eta = 0, \quad \zeta = -f\frac{\tan\theta \cdot \sec v \sec^2\frac{1}{2}v}{1 + \tan v \tan\theta} = d \cdot \frac{1+a}{1+b} \ldots \quad (C)$$

$$\phi = \frac{3\pi}{2}, \quad \eta = 0, \quad \zeta = -f\tan\theta \cdot \sec^2\tfrac{1}{2}v = d(1-a) \quad \ldots \quad (B)$$

rked that investigations confined to the principal inadequate, inasmuch as they fail to explain the nage in the principal plane itself. The point B ble point lying on the two branches of the curve

d to $\phi=\frac{\pi}{2}$ and $\phi=\frac{3\pi}{2}$. This also is shown by the ion, which gives for the tangents at the point

$$\left.\begin{aligned} b(1-a)\eta \pm 2a\zeta &= 0 \\ \tan\theta\,.\,\eta \pm \tan\tfrac{1}{2}v\,.\,\zeta &= 0 \end{aligned}\right\} \quad \ldots \quad \ldots \quad (5)$$

cate that the tangents are equally inclined to the $\theta$. It will be noticed, however, that J, the numerical e terms of the lowest degree, vanishes at the same cessary to observe therefore that the terms of the sess the terms of lowest degree as a factor when the shes, and continuity is thus preserved. I have vn the terms of the third degree into a form his fact on inspection. Thus when $v=2\theta$ there is hrough which pass the branches corresponding to

$\phi=\frac{3\pi}{2}$. When $v>2\theta$, the points BC A are in ing distance from the centre of the field and from rresponding to the ray reflected at the vertex of

portant now to examine the maximum and s of the coordinates. For a critical value of $\eta$

Again, for a critical value of $\zeta$,

$$-2\tan^2\tfrac{1}{2}v\sin 2\phi\,(1-\tan v\tan\theta\cos\phi)$$
$$=\tan v\tan\theta\sin\phi\,(1+\tan^2\tfrac{1}{2}v\cos 2\phi)\quad\ldots\quad\ldots\quad\ldots\quad(7)$$

This is satisfied by $\sin\phi=0$, *i.e.* $\phi=0$ or $\pi$. The curve at the points A and C crosses the axis of $\zeta$ at right angles. The factor $\sin\phi$ being omitted, the equation reduces to

$$2\tan^2\tfrac{1}{2}v\tan v\tan\theta\cos^2\phi-4\tan^2\tfrac{1}{2}v\cos\phi$$
$$-\tan v\tan\theta\,(1-\tan^2\tfrac{1}{2}v)=0$$

or
$$2ab\cos^2\phi-4a\cos\phi-b\,(1-a)=0$$
$$\therefore\ 2ab\cos\phi=2a\pm\sqrt{[4a^2+2a(1-a)b^2]}$$
$$\therefore\ 2ab\cos\phi=2a\pm[2a+\tfrac{1}{2}b^2(1-a)-\ldots]$$

The upper sign is impossible, for it would make $\cos\phi>1$. The lower sign, if higher powers of $b$ be neglected, gives

$$\cos\phi=-b\,(1-a)/4a=-\tan\theta/2\tan\tfrac{1}{2}v.$$
$$\therefore\phi=\pi\pm\cos^{-1}\frac{\tan\theta}{2\tan\tfrac{1}{2}v}\quad\ldots\quad(\mathrm{H},\mathrm{H}')$$

8. These values of $\phi$ give minimum values of $\zeta$ which become impossible when $v$ is small, the limit occurring when $v=\theta$ approximately. After the disappearance of these minima as the centre of the mirror is approached the true minimum is given by $\phi=\pi$. It is then theoretically important to determine $v$ so as to make $\zeta$ an absolute minimum. Now

$$\zeta=-f\tan\theta\frac{\sec^2\tfrac{1}{2}v}{\cos v+\sin v\tan\theta}$$

Hence for a minimum

$$\sec^2\tfrac{1}{2}v\tan\tfrac{1}{2}v(\cos v+\sin v\tan\theta)=\sec^2\tfrac{1}{2}v(-\sin v+\cos v\tan\theta)$$
$$\therefore\tan\tfrac{1}{2}v(1-\tan^2\tfrac{1}{2}v+2\tan\tfrac{1}{2}v\tan\theta)+2\tan\tfrac{1}{2}v$$
$$-(1-\tan^2\tfrac{1}{2}v)\tan\theta=0$$
$$\therefore\tan\theta=\frac{3\tan\tfrac{1}{2}v-\tan^3\tfrac{1}{2}v}{1-3\tan^2\tfrac{1}{2}v}=\tan\tfrac{1}{2}v$$
$$\therefore v=\tfrac{2}{3}\theta.$$

This value of $v$ leads to

$$\zeta=-f\sin\theta\sec^3\tfrac{1}{3}\theta.$$

Also it is easy to see that the maximum value of $\zeta$ corresponds to $\phi=0$ and is by (A)

$$\zeta=-f\sin\theta\,.\,\sec^2\tfrac{1}{2}v\sec(v+\theta),$$

which again is greatest when $v$ corresponds to the edge of the mirror. The total length of the complete geometrical image is therefore

$$l=f\sin\theta\,[\sec^2\tfrac{1}{2}v\sec(v+\theta)-\sec^3\tfrac{1}{3}\theta]\quad\ldots\quad(8)$$

and products of $v$ and $\theta$ of the fifth order be
xpression obtained becomes

$$l = \tfrac{1}{12} f\theta(3v+2\theta)^2.$$

ssion is of purely theoretical interest and does
ly to a reflector as adapted for photographic use,
l part of the mirror is cut off by the plate-holder
of the image is lost (*see* §15).

*ral Tennant's Paper* (*Monthly Notices*, vol. xlvii.
low here General Tennant's own notation. He
250) the equations of the reflected ray thus: in

$$y_0 - av = \frac{4c-4v-cv^2}{4+4cv-v^2}\left(x-\frac{av^2}{4}\right)$$

e XZ$_0$

$$Z_0 = \frac{(av^2}{4}-x)\tan\alpha\sin\phi.$$

he latter equation is incorrect. Simple geome-
ions would show that this is so, but perhaps the
y method will be to find the right equation which
stituted for the preceding.



Now the point of incidence $P_1$ of the ray on the mirror is $(\frac{1}{4}av^2, av, 0)$, the axes being $X_0\ Y_0\ Z_0$. If then $v = 2\tan\psi$, $\psi$ is the angle between the axis of the mirror and the normal at $P_1$. We are chiefly concerned with the directions of certain lines, and we therefore construct a spherical figure (fig. 1) by drawing parallels through the centre of a sphere. Let X Y Z, X $Y_0$ $Z_0$ correspond to the two sets of axes and I, G, R to the incident ray, the normal and the reflected ray respectively. We notice that YXI, $Y_0$XG, and IGR lie on the same great circles and that IG = GR. Let $Y_0$I and $Y_0$R cut $Z_0$X in B and C, and let $BX = BY_0X = \beta$ and $XC = XY_0C = \gamma$. The points B and C correspond to the projections of the incident and reflected rays on the plane $XZ_0$. Hence the equations of these projections are:

$$z_0 = (x - \tfrac{1}{4}av^2)\tan\beta$$
$$z_0 = (\tfrac{1}{4}av^2 - x)\tan\gamma.$$

On $Y_0$G produced we take T so that $GT = XG = \psi$. Then the triangles XGI, TGR are altogether equal, and consequently $RT = IX = \alpha$ and $GTR = GXI = YXY_0 = \phi$. Hence from the triangle $Y_0$TR, in which $Y_0T = \frac{\pi}{2} + 2\psi$ we get

$$-\sin 2\psi\cos\phi = \cos 2\psi\cot\alpha - \sin\phi\cot\gamma.$$

And from the triangle $Y_0$XI

$$0 = \cot\alpha - \sin\phi\cot\beta.$$

We have then

$$\tan\beta = \sin\phi\tan\alpha$$

and

$$\tan\gamma = \frac{\sin\phi}{\cos 2\psi\cot\alpha + \sin 2\psi\cos\phi}$$
$$= \frac{(4+v^2)\sin\phi\tan\alpha}{4+4cv-v^2}$$

We see then that General Tennant has in effect made the tacit assumption that $\gamma = \beta$. If we avoid this error and proceed with the transformation by means of the formulæ

$$y = y_0\cos\phi - z_0\sin\phi$$
$$z = y_0\sin\phi + z_0\cos\phi$$

we shall obtain the equations of the reflected ray in the proper form and arrive at results equivalent to those found in §§ 3 and 4. The oversight is most unfortunate, as it detracts from an otherwise admirable paper, which, so far as I am aware, contains the first serious discussion of the subject under consideration.

10. *On Mr. Schaeberle's Paper* (*A. J.* No. 435).—Mr. Schaeberle's paper is based on a very elementary geometrical method which does not, however, tend to simplify the results. His

ained in this review of his theory. The principal

$$\frac{1}{2}v\cos A+\frac{\cos v\sin\frac{1}{2}\phi\cos(180^\circ+A+B)}{\sin(I-\frac{1}{2}\phi)}\Big] \quad (15\ S)$$

$$\frac{1}{2}v\sin A+\frac{\cos v\sin\frac{1}{2}\phi\sin(180^\circ+A+B)}{\sin(I-\frac{1}{2}\phi)}\Big] \quad (16\ S)$$

be added the subsidiary relations

$$\sin A$$
$$^2\tfrac{1}{2}v+\tan^2\theta-2\tan\tfrac{1}{2}v\tan\theta\cos A] \quad \dots (7\ S)$$
$$\cos B \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (8\ S)$$
$$\cos\theta\sqrt{[\tan^2\tfrac{1}{2}v+\tan^2\theta-2\tan\tfrac{1}{2}v\tan\theta\cos A]} \quad (9\ S)$$

attached to these equations correspond to those Schaeberle's paper. His equation (7), however, r the radical the term $-2\tan v\tan\theta\cos A$, an rint which is corrected above. I shall now show nations, unpromising as they may appear, can be imple expressions for the coordinates in the focal nt to those already found. It is merely necessary I, and $\phi$. We have, from (7 S),

$$B=[\tan\tfrac{1}{2}v-\tan\theta\cos A]/p$$

$$p^2=\tan^2\tfrac{1}{2}v+\tan^2\theta-2\tan\tfrac{1}{2}v\tan\theta\cos A.$$

We can now substitute in (15 S). Thus:

$$\frac{x}{F} = \sec^3 \tfrac{1}{2}v \left[\sin \tfrac{1}{2}v \cos A - \frac{\cos \tfrac{1}{2}v \,(\tan \tfrac{1}{2}v \cos A - \tan \theta)}{1 + \tan v \tan \theta \cos A}\right]$$

$$= \frac{\left[\sin \tfrac{1}{2}v \tan v \tan \theta \cos^2 A + \cos \tfrac{1}{2}v \tan \theta\right]}{1 + \tan v \tan \theta \cos A} \sec^3 \tfrac{1}{2}v$$

$$\therefore x = \frac{F \tan \theta}{\cos v} \cdot \frac{1 + \tan^2 \tfrac{1}{2}v \cos 2A}{1 + \tan v \tan \theta \cos A}.$$

And similarly, by substituting in (16 S), we get

$$\frac{y}{F} = \sec^3 \tfrac{1}{2}v \left[\sin \tfrac{1}{2}v \sin A - \frac{\sin \tfrac{1}{2}v \cos A}{1 + \tan v \tan \theta \cos A}\right]$$

$$= \sin \tfrac{1}{2}v \tan v \tan \theta \sin A \cos A \frac{\sec^3 \tfrac{1}{2}v}{1 + \tan v \tan \theta \cos A}$$

$$\therefore y = \frac{F \tan \theta}{\cos v} \cdot \frac{\tan^2 \tfrac{1}{2}v \sin 2A}{1 + \tan v \tan \theta \cos A}.$$

These formulæ for $x$ and $y$ become identical with those given for $\zeta$ and $\eta$ in (2) when it is remembered that A is the angle which I have called $\phi$ and that $\theta$ is reckoned positive in opposite directions by Mr. Schaeberle and myself, *i.e.* that we assume the star to be on opposite sides of the axis of the mirror.

11. But though Mr. Schaeberle may claim that his formulæ are essentially correct, the same cannot be said of the figure 2 which appears on p. 19 of his paper. He has drawn two curves for $\theta = 30'$ corresponding to the zones for which $v = 5°$ and $v = 3°$. The larger curve in particular is far from accurate. With regard to the drawing of this curve the following points may be noticed: (1) it is obviously of a degree higher than the fourth, for a straight line can be drawn to cut it in six points; (2) the two loops do not cut the axis of $x$ at right angles, but possess singular points where they cross this axis; (3) the points for which A is 90° and 270° do not lie on the axis of $x$; (4) the most serious error lies in the disparity between the width of the loops, the true difference being of the order 1 in 1000. With the exception of (3) the same criticisms apply also to the smaller figure. It is impossible for me to trace the cause of these errors. Possibly the supposed misprint to which I have referred is really a slip. It seems more likely that the responsibility rests with the ambiguous signs which occur in connection with the irrational expressions left in the equations. Finally it may be that the arithmetic is at fault. I give drawings of the curves (fig. 2), which I hope will be found more satisfactory. I venture to deprecate the tendency to refer to the simple geometrical aberration of the parabolic mirror as "Schaeberlian." With all proper respect for Mr. Schaeberle's work I cannot help regarding this title as unnecessary and inappropriate.

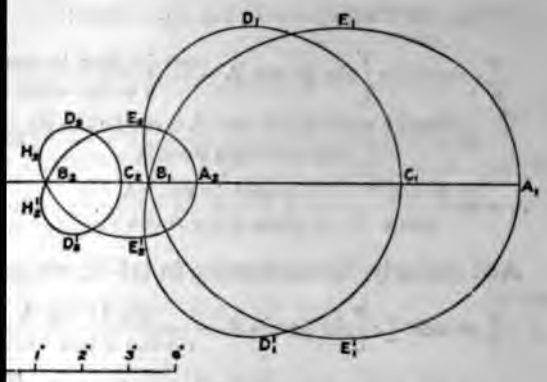



FIG. 2.

*Mr. Crockett's Paper* (*Ap. J.* vii. p. 362).—I shall ockett's final formulæ by deducing from them equa- ent to (2). The set of relations marked (5) in his llows :—

$$\left.\begin{aligned} r_1 &= \frac{r \sin \alpha}{\sin (\gamma + \alpha)} \\ \cos \gamma &= \sin \theta \cos (\psi_1 - \psi) \\ \sin \gamma &= \frac{\sin (\psi_1 - \psi)}{} \end{aligned}\right\} \quad \ldots \quad \ldots \quad (5\ \mathrm{C})$$

If then we put

$$R = -\frac{f \sec^2 \frac{1}{2}\theta \sin \alpha \cos \psi}{\cos \theta \cos \alpha - \sin \theta \sin \alpha \cos \psi}$$

we shall have

$$\begin{aligned} x_1 = r_1 \cos \psi_1 &= R \cos \psi_1 \sec (\psi_1 - \psi) \\ &= R\{\cos \psi - \sin \psi \tan (\psi_1 - \psi)\} \\ &= R \sec \psi(\cos^2 \psi + \cos \theta \sin^2 \psi) \\ &= R \sec \psi(\cos^2 \tfrac{1}{2}\theta + \sin^2 \tfrac{1}{2}\theta \cos 2\psi) \end{aligned}$$

and

$$\begin{aligned} y_1 = r_1 \sin \psi_1 &= R \sin \psi_1 \sec (\psi_1 - \psi) \\ &= R\{\sin \psi + \cos \psi \tan (\psi_1 - \psi)\} \\ &= 2R \sin \psi \sin^2 \tfrac{1}{2}\theta. \end{aligned}$$

Hence, replacing R by the expression which it denotes, we get immediately

$$x_1 = -\frac{f \tan \alpha}{\cos \theta} \cdot \frac{1 + \tan^2 \frac{1}{2}\theta \cos 2\psi}{1 - \tan \theta \tan \alpha \cos \psi}$$

$$y_1 = -\frac{f \tan \alpha}{\cos \theta} \cdot \frac{\tan^2 \frac{1}{2}\theta \sin 2\psi}{1 - \tan \theta \tan \alpha \cos \psi}$$

and these equations again, except for changes of notation, are identical with those numbered (2).

13. In figures 4 and 5 on p. 365 of his paper Mr. Crockett has given a number of curves obtained by assuming $\alpha = 1°$ and giving $\theta$ a series of values from 0° to 3°. Most of these curves have little or no significance in a practical study of the photographic instrument (see § 15), but their variations of form are theoretically interesting and I am glad that this part of the study can be completed by a reference to Mr. Crockett's work. I only wish to point out how his curves exemplify the theory of §§ 6–8. When $\theta = 3°$ (I follow here Mr. Crockett's notation) the resulting H curve is of the same type as those of fig. 2. When $\theta = 2° = 2\alpha$ the G curve possesses the triple point which results from the coincidence of the points B and C. As $\theta$ becomes smaller the point I have denoted by C, passing to the other side of B, approaches the true image for the central point of the mirror, and the F curve given by $\theta = 1\frac{1}{2}°$ has two loops on the side of C towards the centre of the field. The point C coincides with the true image when

$$\sec \theta \sec^2 \tfrac{1}{2}\theta = 1 + \tan \theta \tan \alpha$$

or approximately,

$$1 + \tfrac{1}{4}\theta^2 = 1 - \tfrac{1}{2}\theta^2 + \alpha\theta.$$

This gives $\theta = \frac{4}{3}\alpha$, and in fact when $\theta = 1\frac{1}{3}°$ the E curve is given passing through the point image given by $\theta = 0°$. Mean-

ops mentioned have disappeared and the correspond-
$\theta$ can be estimated by identifying the maximum of $y_1$
D with the minimum of $x_1$ at the point H. This gives

$\cos\frac{\pi}{4}$ or $\theta = \sqrt{2}\,.\,a$ approximately. With $a = 1°$,
$51''$, which agrees satisfactorily with Mr. Crockett's
$1°\ 25'$. The complete curve for smaller values of $\theta$
wo loops, one of which includes the point image given
When $\theta = a = 1°$, a case for which the D curve is
Ir. Crockett, the symmetrical pair of points H, H′
minimum disappear, the geometrical meaning being
oint denoted by C the curve ceases to be concave and
vex to the centre of the field. Finally the point of
nearest to the centre of the field is given by
′, and after this point is reached the curves arising
er zones of the mirror contract in size and approach
ich in a certain sense is the true geometrical image.
t's curves are therefore in agreement with what the
ry would lead us to expect.

*ny previous paper* (*Astronomical Journal, No.* 435).
ates of a point of the image in the focal plane are
form :

$$\frac{2yz\,(f+x)\sin\theta}{(4f^2-r^2)\cos\theta-4fz\sin\theta}$$

$$\frac{\sin\theta\{4f^3+2fz^2-x(y^2-z^2)\}}{(4f^2-r^2)\cos\theta-4fz\sin\theta}$$

or, as we may now write them,

$$\eta = -f \tan\theta \,.\, \tan^2 \tfrac{1}{2}v \sin 2\phi \quad \ldots \quad \ldots \quad \ldots \quad (9)$$
$$\zeta = -f \tan\theta \{1 + \tan^2 \tfrac{1}{2}v \,(2 + \cos 2\phi)\}$$

Now the aberration contains terms of the order $v^2$. Hence it is in general perfectly justifiable to neglect terms of the order $v^4$, $v^3\theta$, or $v^2\theta^2$ for practical purposes. If this is done the approximation to $\eta$ is seen to be adequate. On the other hand a proper approximation to $\zeta$ is

$$\zeta = -f \tan\theta \{1 + \tan^2 \tfrac{1}{2}v \,(2 + \cos 2\phi) + \tan v \tan\theta \cos\phi\} \quad (10)$$

which differs from the preceding expression for $\zeta$ by the addition of the term $-f \tan\theta \,.\, \tan v \tan\theta \cos\phi$.

15. The effect of this term is to make the curve of the zone image depart considerably from the two coincident circles previously found, unless $\theta$ is small compared with $v$. The maximum value of the term when $v = n°$ and $\theta = 1°$ is about $n''$, and of course it diminishes fairly rapidly towards the centre of the field. It introduces distortion apart from more change of scale value. When $\phi = \frac{\pi}{2}$ or $\frac{3\pi}{2}$ the term vanishes, and when $\phi$ is given values differing by $\pi$, the corresponding points are equidistant from the point given by (9) and the following equation. Hence the circle which is the locus corresponding to the latter equations may be regarded as a mean between the two loops represented by (9) and (10). This affords in many cases a justification for neglecting the term when $v$ is fairly large; and when $v$ is small, although the form of the curve as shown in the review of Mr. Crockett's paper undergoes considerable changes, the omission has little practical effect. This is due partly to the smallness of the curves and partly to the shadow which the photographic plate and its holder cast on the mirror. In the direction $\phi = \pi$ the light is evidently intercepted at least as far as the zone $v = 2\theta$. In the plane $\phi = \frac{\pi}{2}$ and $\frac{3\pi}{2}$ the zone $v = a$ is ineffective, $2a$ being the angular width of the field covered by the plate. The result is that the curves considered do not contribute much to the image, especially in the case of stars at some distance from the edge of the plate. The images are thus deprived of the fairly sharp point directed towards the centre of the field, and the geometrical focus for the centre of the mirror will in general lie nearer the focus of the surface than any point of the image actually formed. The precise effect in actual measurement can only be determined by experiment. With the reservation now stated I still consider the analysis of the distribution of intensity in the image, developed in my former paper, fairly satisfactory as a first approximation, and it is probably not worth while to push further a purely geometrical investigation. That examination seems certainly preferable to the merely general explanations

re and will serve at least to emphasise the necessity ention to the effect of star magnitude and time of ıe reduction of a photograph taken with a parabolic

*form of the image in a plane parallel to the focal* he reflected ray meet the plane $x = f - h$ in the . Then

$$\eta = y + \frac{\mu}{\lambda}(f - h - x) = \eta_0 - \frac{\mu}{\lambda} . h$$

$$\zeta = z + \frac{\nu}{\lambda}(f - h - x) = \zeta_0 - \frac{\nu}{\lambda} . h,$$

ıre the co-ordinates of the corresponding point in e already found in § 4. Now in the coefficients of of the first order in $v$, we may fairly neglect terms order in $v$ and $\theta$. This will give as sufficient ıs to (1)

$$\mu/\lambda = -\sin\phi \tan v$$
$$\nu/\lambda = -\cos\phi \tan v - \tan\theta.$$

ɣ a consistent degree of approximation throughout, $\zeta_0$ the forms (9) and (10) of § 14. Thus

$$\text{an } \theta \tan^2 \tfrac{1}{2} v \sin 2\phi + h \tan v \sin\phi$$
$$\text{an } \theta \{1 + \tan^2 \tfrac{1}{2} v (2 + \cos 2\phi) + \tan v \tan\theta \cos\phi\}$$

the variation of $\phi$ between 0 and $\pi$ and between $\pi$ and $2\pi$. Then (9) and the following equation may be written

$$\eta = -\rho \sin \phi \ .$$
$$\zeta = -f \tan \theta \sec^2 \tfrac{1}{2}v - \rho \cos \phi,$$

which show that the final approximations of my former paper represent a circle which, as there explained, generates a kite-shaped image of angle 60° (fig. 3*a*). Now (9) and (10) differ from the equations just considered only in the addition of the term $-f \tan^2 \theta \tan v \cos \phi$ to $\zeta$. The nature of the modification thus introduced is easily understood, and is illustrated in fig. 3*b*. It would then be possible to deduce the character of the locus represented by (11) from the locus last considered by changing $f$ into $f'$ in the circular terms, $f \tan^2 \theta$ into $(f' \tan^2 \theta - h)$ in the correcting term of $\zeta$, and finally applying to $\eta$ the term $h \tan v \sin \phi$. It seems better, however, to discard the circular approximation (except as a guide to position) and to put

$$\rho = 2f' \tan \theta \tan^2 \tfrac{1}{2}v \cos \phi - h \tan v \quad \ldots \qquad \ldots \quad (13)$$

This is the polar equation of a limaçon. If the term $-f' \tan^2 \theta \tan v \cos \phi$ in $\zeta$ be neglected for the moment (11) may now be written

$$\eta = -\rho \sin \phi$$
$$\zeta = -f' \tan \theta \sec^2 \tfrac{1}{2}v - \rho \cos \phi.$$

It would be tedious and unnecessary to consider possible varieties of form in detail. It is sufficient to take the case in which the limaçon is of the two-looped kind, in which case the relation to the previous double-circular approximation is obvious. The node is at the pole, which is in the same position as in the former case. The positions of two pairs of points are important. These are K, L (fig. 3*c*), given by

$$\phi = \frac{\pi}{2} \text{ and } \frac{3\pi}{2}, \ \eta = \pm h \tan v, \ \zeta = -f' \tan \theta \sec^2 \tfrac{1}{2}v$$

and M, N given by

$$\phi = 0 \text{ and } \pi, \ \eta = 0, \ \zeta = -f' \tan \theta \sec^2 \tfrac{1}{2}v - 2f' \tan \theta \tan^2 \tfrac{1}{2}v \pm h \tan v$$

These points serve to fix the position of the limaçon in relation to the circle obtained by putting $h = 0$.

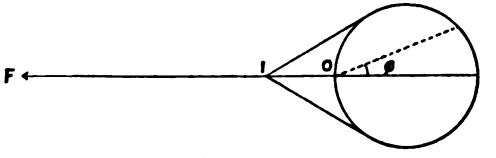



FIG. 3*a*.

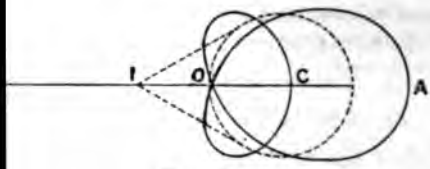



Fig. 3*b*.

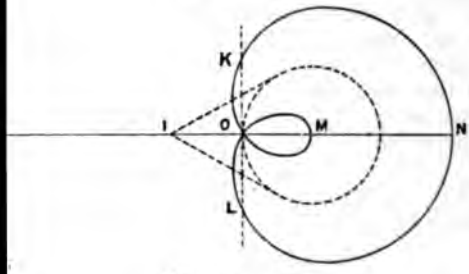
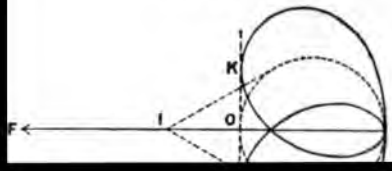



Fig. 3*c*.



special circumstances seem to make it desirable to make a compromise by adjusting the photographic plate so as to get the best definition, or rather the minimum radial aberration at a distance $\theta$ from the centre of the plate, then the proper position is given by

$$h = f \tan^2 \theta,$$

in which case the image is generated by a point whose coordinates are

$$\left.\begin{aligned} \eta &= -f' \tan\theta \tan^2 \tfrac{1}{2}v \sin 2\phi + f' \tan^2\theta \tan v \sin\phi \\ \zeta &= -f' \tan\theta \{1 + \tan^2 \tfrac{1}{2}v\,(2 + \cos 2\phi)\} \end{aligned}\right\} \quad \ldots \quad (14)$$

The use of curved plates seems also to offer no advantage sufficient to warrant the extra trouble and expense. The proper radius of curvature for such plates is now found to be

$$R = f^2 \tan^2\theta / 2h = \tfrac{1}{2}f \quad \ldots \quad \ldots \quad (15)$$

a result which is in agreement with the well-known curvature of the field in its usual conventional sense. The impossibility of effectively overcoming the aberration of a parabolic mirror by any device of the kind considered has also been stated by Mr. S. C. Reese (*Astrophysical Journal*, vol. xii. p. 227), after an investigation of a very different kind. As the nature of the images depends on curves given by (14) a typical curve is sketched (fig. 3*d*) with the circle to which it is related in the manner already explained.

19. In conclusion a word or two of summary may be added to what has already been said in § 2 of the critical part of this paper. I still believe that my former paper (*A. J.* No. 435), which gives fig. 3*a* as a fair approximation, may be considered a satisfactory *general* explanation of the nature of the image formed by a parabolic mirror. Moreover its method and results have been of great service in the extension given to the theory in §§ 16–18 above. But confessedly accuracy has in a slight degree been sacrificed for the sake of simplicity. If then my work is to be of use in designing a parabolic mirror for a definite purpose, it will be easy to draw the necessary curves with absolute accuracy with the help of equations (2) of § 4 of the present paper. In most cases the simpler approximate forms (9) and (10) of § 14 will be sufficient. The discussion given in §§ 16–18 is necessarily brief, but it will suffice, I hope, to prove the negative result that more or less kite-shaped images are unavoidable in the case of a reflector as ordinarily adapted for photographic use.

*University Observatory, Oxford:*
1902 *March* 10.

*Spectrum, Sumatra Eclipse,* 1901 *May* 18.

By S. A. Mitchell, Ph.D.

(*Communicated by Professor J. K. Rees.*)

rency accompanying this paper contains :
of the Second Flash.
taken 5 seconds after Second Flash.
were photographed with an objective plane
positives made without enlargement.

hrough the courtesy of the former astronomical
Naval Observatory, Professor S. J. Brown,
er of the expedition to view the Sumatra eclipse

ing the island, it had been decided to occupy two
ervations on the eclipse ; one, Solok, near the
totality, the other Fort de Koch, near the
the Moon's shadow path.
al in the East Indies, it was soon found that the
was going to be clouds, for almost at no time
was the sky perfectly clear. It was, therefore,
subdivide the party at Solok, and a third station
Sawah Loento, about twenty miles distant, at the

# UNITED STATES NAVAL OBSERVATORY

## SUMATRA ECLIPSE EXPEDITION

May 18, 1901

5 sec. after Second Flash — Exposure ½ sec.





Second Flash — Exposure 3 sec.

Photographed with an OBJECTIVE PLANE GRATING

BY

S. A. MITCHELL, Columbia University Observatory, New York City

MONTHLY NOTICES, ROYAL ASTRONOMICAL SOCIETY, VOL. LXII. PLATE 8



in a perfectly cloudless sky, but soon after this clouds began to gather, and a quarter of an hour before second contact the sky was completely overcast.

The disappearing crescent of the Sun was watched by a binocular, before one half of which was arranged a small plane grating in such a way that with one eye the spectrum could be seen, with the other the Sun itself.

With this, shortly before the time of second contact, bright lines were seen for a few seconds at F and H, and in several places in the green and yellow, but these disappeared almost immediately, the Sun again being completely hidden by clouds—and the first flash passed without our being able to see it.

Towards the middle of totality conditions became a trifle better, so that it was possible to see, through clouds, the corona extending for about half a diameter from the Sun, and with the small spectroscope the "coronium line" quite distinctly. During no time of the $5^m\ 41^s$ of totality was an unclouded view of the corona obtained, but nevertheless the second flash was seen beautifully.

An hour after totality the clouds cleared away and a perfect sky remained for the rest of the afternoon!

Altogether eight exposures were made, one before and one just after totality for the cusp spectrum, one at first and one at second flash, and four with different lengths of exposure during the total phase. The first flash is entirely lacking, clouds having completely cut off all the light; the second flash seemed fully exposed, and it is to the discussion of its photograph that this paper is devoted.

*The "Flash."*—The peculiarities of this photograph of the flash are twofold:

1. Normal spectrum.
2. Great dispersion.

On the plate, the distance from F to H is 95·4 mm., and, as the spectrum is normal, 1 mm. therefore corresponds to a difference of wave-length of 9·37 tenth-metres, or 1 tenth-metre corresponds to a dispersion of about 0·1 mm. This is about one-fifth the dispersion obtained with the ordinary Rowland mounting with a 21½-foot grating of 20,000 lines.

For some reason the spectra were not in perfect focus, and it was thus practically impossible to measure the cusp spectra. Owing to the great dispersion, although the bright lines of the flash were not perfectly sharp, measures were made and wave-lengths determined with a high degree of accuracy.

The plate was measured by one of the Repsold machines belonging to Columbia University, by comparing the spectrum lines directly with a millimetre scale. Measures with this machine can be made directly to 0·005 mm., and by estimation to 0·0005 mm., *i.e.* to 0·005 λ. However the sharpness of the lines did not permit them to be carried to this degree of accuracy

*Comparisons with the Solar Spectrum.*—Those who have

ntify the bright lines with Rowland's map know
his undertaking, which arise from the differences
ween the solar spectrum and the flash, but more
ne great differences of intensities of the lines in
Great care was exercised in the determinations
gths and in the comparisons with Rowland's
l wave-lengths.
extends from λ 4924 to λ 3320, but the focus
the violet end beyond K, and measures were
λ 3835, Hη. The photograph from F to H was
and for the present purposes considerations are
egion.
and He lines, 374 lines were measured in the
and H ; 91 of these were unidentified, 283
nes in the solar spectrum. An arbitrary scale
as assumed where 0 denotes a line seen with
strongest line of the spectrum.
are immediately noticed in comparing the two
r each and every element, the brighter the solar
the flash line corresponding to it ; second, the
solar lines which correspond to a line of given
e flash differ with different metals. Fe and Ni
5, Ti, Sc, and V lines of intensity 2, are identified
of equal strength. These differences for the
were so marked that in order to arrive at their
hence draw some conclusions regarding the
three tables were made. The first contains the
ed according to metals and intensities of lines

TABLE I.

*Group I.—Lines strong in flash, and in solar spectrum.*

| Element. | Atomic Weight. | Number of Lines Identified. | Intensity Flash / Intensity Solar Lines. | Number Lines Identified / Total Number Lines. |
|---|---|---|---|---|
| Na | 23·0 | — | — | — |
| Mg | 24·3 | 1 | 0·10 | 1·00 |
| Al | 27·1 | — | — | — |
| Ca | 40·0 | 8 | 0·34 | 0·38 |

*Group II.—Lines strong in flash, weak in solar spectrum.*

| | | | | |
|---|---|---|---|---|
| Sc | 44·1 | 6 | 0·81 | 0·75 |
| Ti | 48·1 | 62 | 0·68 | 0·70 |
| V | 51·2 | 15 | 0·68 | 0·67 |
| Cr | 52·1 | 38 | 0·55 | 0·69 |
| Mn | 55·1 | 27 | 0·24 | 0·48 |
| Sr | 87·6 | 2 | 1 08 | 0·67 |
| Y | 88·7 | 2 | 0·50 | 0·67 |
| Zr | 90·6 | 9 | 0·46 | 0·70 |

*Group III.—Lines weak in flash, strong in solar spectrum.*

| | | | | |
|---|---|---|---|---|
| Fe | 56·0 | 125 | 0·23 | 0 32 |
| Ni | 58·7 | 9 | 0·36 | 0·28 |
| Co | 59·0 | 6 | 0·19 | 0 29 |

Looking at the numbers of the two last columns we see that the lines naturally fall into three groups as given in the table.

To these may also be added the following lines :

La, atomic weight 138·5, 3 lines at λ 4123·384, λ 4217·720, and λ 4613·544.

Ba, atomic weight 137, 1 line at λ 4554·211,

and the following lines possibly identified :

Si, atomic weight 12, 1 line at λ 3905·660,

Zn, atomic weight 65, 1 line at λ 4810·724,

Ce, atomic weight 92, 2 lines at λ 4003·912 and λ 4107·649.

In Group I. would also fall Al, if we consider the relative intensities of the two lines λ 3944·160 and λ 3971·674 ; and undoubtedly Na, if our plate took in the D lines.

The grouping of these lines is exactly that adopted by Evershed from his investigations of the Indian eclipse, except I have put Zr with Sr and V in Group II. Mn seems to represent the transition from Group II. to Group III.

As Evershed has pointed out, the remarkable variations of the relative intensities in the flash and Fraunhofer spectra are undoubtedly due to the heights to which the vapours of the different metals ascend in the chromosphere. We would natur-

t these heights vary according to the atomic
etals, those of least atomic weights ascending to
tances ; and generally speaking this no doubt is
have two gases in the Sun's atmosphere, one a gas
brightness 1 and 100 miles in thickness, it would
hic line in the flash spectrum just as bright as
intrinsic brightness 100 and only 1 mile thick, *if*
on were relatively at rest during the period of
considering the gradual advance of the Moon
uccessive layers of the Sun's atmosphere we see
sion spectrum the photographic brightness of the
ld be many times that of the brighter. The
ed by a gas depends on the total number of
ar ray comes in contact with, and will be very
he two cases.

hese considerations it would therefore seem that
metals of Group II. extend very high, that they
much condensed, and that practically all the gas
e formation of the emission line, and hence, the
be regarded as true reversals of the corresponding

of Groups I. and III. are somewhat condensed
urface (those of Group I., particularly Ca, reach
nts than those of Group III.), but as it is the
hat contributes most to the formation of the
wing to the progressive motion of the Moon,
re to be regarded as only partial reversals of
ines, the solar intensities being greater than the

## *The Duration of Totality at Navalmoral.*

By C. T. Whitmell, M.A., B.Sc.

For the total solar eclipse of 1900 May 28 I have shown, by a comparison of a large number of observations of the predicted and observed durations of totality for several localities, that the eclipse semidiameter of the Moon, adopted by the *British Nautical Almanac*, is too large. (See *Total Solar Eclipse of* 1900, pp. 75–81.) In the present paper I propose to give some details with regard to Navalmoral, whence I observed this eclipse.

For Navalmoral the following data were published by Dr. Downing :—

Adopted position, 5° 34′ W. longitude, 39° 52′ N. latitude.

| | | G.M.T. h m s |
|---|---|---|
| Eclipse begins ... ... | May 28 | 2 48 45 |
| Totality „ ... ... | „ | 4 6 12 |
| Totality ends ... ... | „ | 4 7 39 |
| Eclipse „ ... ... | „ | 5 15 45 |

| | Angle from N. Point. ° |
|---|---|
| First contact ... ... ... ... | 273 |
| Second „ ... ... ... ... ... | 99 |
| Third „ ... ... ... ... ... | 267 |
| Fourth „ ... ... ... ... ... | 93 |

A note was appended to the effect that the predicted duration of totality (87ˢ) is perhaps 3ˢ too long.

The duration of totality at Navalmoral was carefully timed independently by four observers, and we agreed upon a totality of 80ˢ. Mr. Howarth, F.R.A.S., the Rev. S. J. Johnson, F.R.A.S., and Mr. Southall used only the eye unaided.

I observed with a low-power binocular, of which the right object-glass was fitted with a diffraction grating attached to a prism, so that the beginning and the ending of totality were estimated by the disappearance and the reappearance of the normal solar spectrum. The coincidence in the four estimates seems to afford reasonable ground for believing that the duration of totality was, as nearly as possible, 80ˢ.

There is thus a loss of at least 7ˢ to be accounted for, and this may be due to :—(*a*) errors in the lunar tables, (*b*) error in the adopted position of Navalmoral, (*c*) error in the *N.A.* value of the Moon's geocentric semidiameter, which for eclipses is 15′ 32″·65 at mean distance. It is assumed that the *N.A.* eclipse semidiameter of the Sun is correct.

to (*a*) it should be noted that, as the transit of the Sun was practically central, it may be inferred ble error in the Moon's tabular latitude would be eciably to alter the duration of totality.

eñor Iñiguez, of the Madrid Observatory, has plied the exact position of Navalmoral Church. are 5° 32′ 29″ W. longitude, and 39° 53′ 29″ N. ference from the originally adopted coordinates ″ in longitude and 1′ 29″ in latitude.

a, at mid-totality, $4^h\ 6^m\ 56^s$, G.M.T., the centre vas in 5° 31′ 45″ W. longitude, and 39° 53′ 40″ rdinates differing by only 44″ of longitude and rom the position of the church as given by Señor e were about half a mile N. of the church we 20″ of latitude N. of the central line, so small a r us the transit of the Moon over the Sun was ral during totality.

w to consider (*c*). Adopting for Navalmoral the y Señor Iñiguez, and using *N.A.* data for the R.A., iameters of the Sun and Moon, I have made for d $4^h\ 10^m$, G.M.T., a careful computation of the Sun and Moon, and obtain a totality duration of second in excess of the *N.A.* predicted value. mid-totality agrees almost exactly with the *N.A.*

The nearest approach of the centres of the Sun bout 0″·3, so that, as already pointed out, the ctically central. The position angle for second 93°, that for third contact is about 271°, reckoned

should have lasted $82^{s}\cdot4$. The loss of $2^{s}\cdot4$, needed to produce agreement with our observations, could be accounted for by a reduction of only $0''\cdot5$ in the Moon's semidiameter, *i.e.* of $1''$ in her diameter. This discrepancy may reasonably be attributed to irregularities in the Moon's limb, as suggested by Mr. Crommelin in *Monthly Notices*, vol. lxi. pp. 52–3. A lunar valley of a depth of about 6,000 feet below the Moon's mean level, or two valleys, the sum of whose depths amounts to 6,000 feet, one valley being near second and the other near third contact, would be sufficient.

As the points of second and third contact were about position angles 93° and 271°, and the Moon's north pole at the time of the eclipse was 11° 13′ W. of her north point, the position angles of contact on the Moon's limb would be about 104° and 282° from her north pole. The Moon's libration in latitude was practically zero, that in longitude was +4°. The position angles may easily be 1° or 2° in error, for an extremely slight deviation from central transit produces a considerable change in these angles. The angles 99° and 267°, given by the *Nautical Almanac*, would apparently correspond to a difference of some $2''$ between the centres of the Sun and Moon about mid-totality.

Adopting the angles 104° and 282°, second contact of the Moon with the Sun would occur near 86° E. longitude and 14° S. latitude, whilst third contact would be near 94° W. longitude and 12° N. latitude. The second contact indicates a region between the Cordilleras and the D'Alembert Mountains. The third contact is not on the lunar maps, being on that face of the Moon not shown by them, but the region indicated is in the neighbourhood (N.W.) of Neper, a walled plain.

Mr. Saunder, to whom I wrote about these localities, remarks that it is not possible, from our present knowledge, to say whether the neighbourhood of the Moon's limb near the contact points is above or below the mean level. But he adds that this information might be obtained from photographs taken during the eclipse, or taken at times when the Moon was under libration, similar to that which she had during the eclipse.

It is well known that the lunar border in the vicinity of second contact was seen to be very irregular during the progress of this eclipse. It will be of interest for some one possessed of suitable lunar photographs to investigate the regions of the Moon's limb referred to above.

Dr. Struve (*Monthly Notices*, vol. lii. p. 283) states that there is no systematic deviation of the form of the Moon's disc from a circle, and Professor Franz (*Monthly Notices*, vol. lxi. p. 264) concludes that the Moon's figure is sensibly spherical. Thus surface irregularities seem to be the only thing left to account for the discrepancy, still outstanding at Navalmoral, when Herr Peters's value of the semidiameter is used.

The estimated value of the Moon's telescopic mean semidiameter has undergone some interesting changes. According to the late Mr. Stone (*Monthly Notices*, vol. xlii. p. 42) the

e for 1750–1815 was 15′ 34″·27 ; for 1816–39 it
95 ; for 1840–61 it was 15′ 34″·68 ; and in and
was 15′ 34″·08. The present (1900) value used in
*Almanac* is 15′ 34″·09, the mean horizontal parallax
28.

Preface to the *Nautical Almanac* for 1897 there
the first time, special values of the semidiameters
nd Moon for use in eclipses and occultations, the
Sun being 15′ 59″·63 (Auwers), and for the Moon
truve). For 1900 the American Ephemeris adopts
r the eclipse semidiameter of the Moon.

ms to be but little doubt that we need to use *three*
es for the Moon's semidiameter ; the largest value
telescopic purposes, the intermediate for the occulta-
, and the smallest for solar eclipses.

raw the attention of those interested in this subject
le article by Professor Oudemans, published in the
*ces*, vol. xxvi. pp. 249–260, 1866 May. He therein
duration of occultations and eclipses, refers to the
ntations on the Moon's limb, and draws the conclu-
r occultations the Moon's mean semidiameter is
out that for eclipses it is only 15′ 31″·02. The
·25 between these values agrees very nearly with
e 1″·18 between the *Nautical Almanac* value,
d that recently deduced by Herr Peters, 15′ 31″·47.
h indebted to Mr. Crommelin for independent con-
he principal computations in this paper.

say, as seen and measured on the photographs, these being expressed as millionths of the Sun's apparent disc; and next areas as corrected for foreshortening, the areas in this case being expressed in millionths of the Sun's visible hemisphere.

Table III. exhibits for each rotation in 1901 the mean daily area of the whole spots, and the mean heliographic latitude of the spotted area, for spots north and for spots south of the equator; together with the mean heliographic latitude of the entire spotted area, and the mean distance from the equator of all spots; and Table IV. gives the same information for the year as a whole, similar results from 1889 to 1900 being added, as in the case of Table II. Tables II. and IV. are thus in continuation of the similar tables for the years 1874 to 1888 on pp. 381 and 382 of vol. xlix. of the *Monthly Notices*.

The rotations in Table I. and Table III. are numbered in continuation of Carrington's series (*Observations of Solar Spots made at Redhill* by R. C. Carrington, F.R.S.), No. 1 being the rotation commencing 1853 November 9. The assumed prime meridian is that which passed through the ascending node at mean noon of 1854 January 1, and the assumed period of the Sun's sidereal rotation is 25·38 days. The dates of the commencement of the rotations are given in Greenwich civil time, reckoning from mean midnight.

TABLE I.

| No. of Rotation. | Date of Commencement of each Rotation. | No. of Days on which Photographs were taken. | Mean of Daily Areas. | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Projected. | | | Corrected for Foreshortening. | | |
| | | | Umbræ. | Whole Spots. | Faculæ. | Umbræ. | Whole Spots. | Faculæ. |
| | 1900. d | | | | | | | |
| 632 | Dec. 24·64 | 26 | 0·0 | 0·5 | 0·0 | 0·0 | 0·3 | 0·0 |
| | 1901. | | | | | | | |
| 633 | Jan. 20·98 | 27 | 2·4 | 8·0 | 13 | 1·9 | 6·6 | 16 |
| 634 | Feb. 17·32 | 26 | 6·9 | 22 | 29 | 5·0 | 16 | 36 |
| 635 | Mar. 16·65 | 26 | 0 0 | 0·0 | 7·0 | 0·0 | 0·0 | 9·8 |
| 636 | Apr. 12·93 | 27 | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 |
| 637 | May 10·18 | 28 | 138 | 339 | 53 | 83 | 231 | 72 |
| 638 | June 6·39 | 27 | 14 | 70 | 34 | 8·8 | 46 | 42 |
| 639 | July 3·59 | 27 | 0·0 | 0·9 | 47 | 0·0 | 1·1 | 54 |
| 640 | July 30 80 | 25 | 0·0 | 0·0 | 6·2 | 0·0 | 0·0 | 6·6 |
| 641 | Aug. 27·03 | 28 | 0·0 | 0·4 | 2·2 | 0·0 | 0·3 | 3·2 |
| 642 | Sept. 23·29 | 27 | 2·5 | 10 | 8·1 | 1·4 | 5·4 | 7·1 |
| 643 | Oct. 20·58 | 27 | 5·2 | 29 | 94 | 5·5 | 31 | 130 |
| 644 | Nov. 16·88 | 27 | 9·7 | 51 | 4·0 | 6·4 | 35 | 7·7 |

TABLE II.

| ays on hoto- were n. | Mean of Daily Areas. | | | | | |
|---|---|---|---|---|---|---|
| | Projected | | | Corrected for Foreshortening. | | |
| | Umbræ. | Whole Spots. | Faculæ. | Umbræ. | Whole Spots. | Faculæ. |
| 0 | 17·9 | 103 | 107 | 13·1 | 78·0 | 131 |
| 1 | 21·3 | 133 | 273 | 15·5 | 99·4 | 304 |
| 3 | 120 | 745 | 1322 | 86·2 | 569 | 1412 |
| 2 | 255 | 1596 | 3230 | 186 | 1214 | 3270 |
| 2 | 327 | 1983 | 2287 | 234 | 1464 | 2404 |
| 4 | 317 | 1728 | 1666 | 231 | 1282 | 1877 |
| 4 | 237 | 1330 | 2059 | 169 | 974 | 2278 |
| 4 | 127 | 745 | 1243 | 90 | 543 | 1410 |
| 4 | 122 | 695 | 977 | 88 | 514 | 1149 |
| 3 | 93 | 532 | 767 | 64 | 375 | 891 |
| 4 | 27 | 159 | 297 | 18 | 111 | 337 |
| 0 | 22 | 101 | 150 | 17 | 75 | 180 |
| 9 | 14 | 41 | 23 | 8·6 | 29 | 29 |

TABLE III.

| of | s on to- re | Spots North of the | Spots South of the | to- ti- ire ea. | nce or a. |
|---|---|---|---|---|---|

TABLE IV.

| Year. | No. of Days on which Photographs were taken. | Spots North of the Equator. | | Spots South of the Equator. | | Mean Heliographic Latitude of Entire Spotted Area. | Mean Distance from Equator of all Spots. |
|---|---|---|---|---|---|---|---|
| | | Mean of Daily Areas. | Mean Heliographic Latitude. | Mean of Daily Areas. | Mean Heliographic Latitude | | |
| 1889 | 360 | 5·0 | 7°·26 | 73·0 | 11°·90 | −10°·68 | 11°·61 |
| 1890 | 361 | 53·1 | 22·20 | 46·3 | 21·75 | + 1·73 | 21·99 |
| 1891 | 363 | 401 | 20·49 | 169 | 19·91 | + 8·52 | 20·31 |
| 1892 | 362 | 607 | 15·09 | 607 | 21·69 | − 3·29 | 18·39 |
| 1893 | 360 | 517 | 14·91 | 941 | 14·26 | − 3·93 | 14·49 |
| 1894 | 364 | 543 | 12·31 | 739 | 15·56 | − 3·75 | 14·18 |
| 1895 | 364 | 565 | 14·26 | 409 | 12·54 | + 3·01 | 13·54 |
| 1896 | 364 | 203 | 13·60 | 340 | 14·77 | − 4·15 | 14·33 |
| 1897 | 364 | 196 | 8·32 | 318 | 7·73 | − 1·62 | 7·96 |
| 1898 | 363 | 110 | 9·82 | 266 | 10·77 | − 4·75 | 10·49 |
| 1899 | 364 | 23 | 6·18 | 88 | 10·43 | − 6·95 | 9·54 |
| 1900 | 360 | 26 | 6·61 | 49 | 8·34 | − 3·12 | 7·74 |
| 1901 | 359 | 22 | 8·59 | 6·6 | 16·27 | + 2·82 | 10·37 |

The principal features of the record for 1901 are :—

1. The decline in area of umbræ, whole spots, and faculæ has still continued, and has been most marked ; the relative decrease in mean daily spotted area for 1901 as compared with 1900 being greater than for 1900 as compared with 1899.

2. The decrease in the area of the umbræ has been proportionally less than that for the whole spots.

3. The decrease in the area of the faculæ on the other hand has been very remarkable. The area registered—twenty-nine millionths—is by far the lowest for any year of the Greenwich solar record, the next lowest being ninety millionths for 1878.

4. Except for a single outburst the northern hemisphere has been practically quiescent for the entire year. But that outburst was so much the greatest that it contributed, in its two appearances, 74 per cent. of the entire spotted area of the year, and in consequence of it the mean daily area for the northern hemisphere was more than three times as great as for the southern.

5. Comparing 1901 with 1900 the decrease for the northern hemisphere was only 15 per cent., whilst for the southern it was 86 per cent. The decrease, therefore, has been almost entirely in the southern hemisphere.

6. The only notable outburst of the year was the group referred to above. This was seen first on the east limb on May 19, the morning after the total solar eclipse of May 18. At the times of the eclipse as seen in Mauritius and Sumatra

the centre of the group was 93° and 92° distant
tral meridian, and therefore only just out of sight
st limb. The group was situated in N. lat. 9°, and
ence is seen in the Mauritius photographs of the
from the limb in N. lat. 6°, *i.e.* just over the
of the spot group. A comparison of the Mauritius
eclipse photographs shows that a considerable
aken place in the form of this prominence in the
out 100 minutes which separated the two series of
To the north of the prominence, and therefore
the spot group itself, the corona is seen on both
ographs as much disturbed.

group appeared a second time on the east limb on
had diminished in size, almost to disappearance,
hed the west limb on June 26.

stribution of the spots in latitude in 1901 shows
y in the mean to seek a higher latitude than in
ups, two in each hemisphere, appearing in latitudes
But the relatively great area of the group of
. lat. 9°, brings the mean distance from the equator
wn to 10°·37. This shows a distinct rise in latitude
en the mean distance was 7°·74. In the closing
preceding cycle the mean distance for 1888 was
r 1889, the year of minimum, 11°·61, whilst for
t year of increased spotted area, it was 21°·99.

mber of days without spots has very greatly in-
having been no fewer than 289 such days out of the
which there are photographs available. On 277

*Results of Micrometer Measures of Double Stars made with the 28-inch Refractor at the Royal Observatory, Greenwich, in the year* 1901.

(*Communicated by the Astronomer Royal.*)

The measures were made with a bifilar position-micrometer on the 28-inch refractor, aperture 28 inches, focal length 28 feet. The power generally used was 670, but when the definition permitted a power of 1120 was employed for observing very close pairs. A blue glass shade was employed to diminish the light and irradiation when bright stars were observed. The observations were made in variously coloured fields or in a dark field with illuminated wires. The initials in the last column are those of the observers, viz. :—

B. Mr. Bryant. L. Mr. Lewis. W.B. Mr. Bowyer.

*Micrometric Observations of Double Stars at the Royal Observatory, Greenwich.*

| Star's Name. | R.A. 1900. | N.P.D. 1900. | Position Angle | Distance. | No. of Nights. | Mags. | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | ° | ″ | | | | |
| Σ 3062 ... | 0 1 | 32 7 | 345·0 | 1·46 | 1 | 6·9 8·0 | ·753 | B. |
| β 253 ... ... | 0 5 | 32 2 | 42·5 | 0·52 | 2 | 8·3 8·4 | ·436 | B. |
| β 485 ... ... | 0 6 | 31 48 | 304·9 | 0·41 | 1 | 8·7 8·8 | ·753 | B. |
| Krueger 1 ... | 0 6 | 32 43 | 186·4 | 1·92 | 1 | 9·2 9·5 | ·753 | B. |
| β 1026 ... | 0 7 | 36 56 | 329·2 | 0·29 | 1 | 8·1 8·9 | ·753 | B. |
| β 864 ... ... | 0 8 | 55 13 | 283·9 | 1·14 | 1 | 8·4 11·5 | ·036 | L. |
| OΣ 2 ... ... | 0 8 | 63 34 | 37·4 | 0·68 | 1 | 6·5 8·0 | ·044 | L. |
| | | | 39·0 | 0·54 | 2 | ... | ·853 | W.B. |
| | | | 36·0 | 0·60 | 2 | ... | ·896 | B. |
| Σ 19 ... ... | 0 12 | 53 55 | 133·9 | 2·06 | 2 | 7·0 9·5 | ·022 | L. |
| | | | 135·5 | 2·22 | 1 | ... | ·890 | W.B. |
| β 1093 ... | 0 15 | 79 34 | 70·7 | 0·28 | 1 | 7·3 8·2 | ·830 | B. |
| β 1015 ... | 0 16 | 78 14 | 113·9 | 0·49 | 1 | 8·4 8·6 | ·835 | W.B. |
| OΣ 7 B.C. | 0 16 | 24 5 | 107·4 | 0·54 | 1 | 9·0 10·0 | ·753 | B. |
| β 1156 ... | 0 21 | 26 7 | 34·5 | 0·45 | 1 | 9·2 9·3 | ·753 | B. |
| OΣ 12 ... ... | 0 26 | 36 2 | 147·1 | 0·42 | 1 | 5·6 5·9 | ·082 | L. |
| | | | 149·5 | 0 55 | 2 | ... | ·436 | B. |
| OΣ 15 ... ... | 0 30 | 41 32 | 311·4 | 0·16 | 2 | 7·5 8·5 | ·436 | B. |
| β 257 ... ... | 0 35 | 43 17 | 229·9 | 0·46 | 1 | 8·1 8·8 | ·753 | B. |
| OΣ 18 ... ... | 0 37 | 86 23 | 128·4 | 1·07 | 1 | 7·4 9·5 | ·835 | W.B. |
| β 865 ... ... | 0 38 | 47 18 | 198·5 | 1·40 | 1 | 8·3 8·8 | ·753 | B. |
| β 866 ... ... | 0 40 | 47 18 | 69·1 | 1·70 | 1 | 9·0 9·1 | ·753 | B. |

| R.A. 1900. | N.P.D. 1900. | Position Angle. | Distance. | No. of Nights. | Mags. | | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|---|
| m | ° ′ | ° | ″ | | | | | |
| 42 | 71 51 | 223·6 | 0·49 | 3 | 7·5 | 7·7 | ·850 | W.B. |
| 43 | 32 43 | 220·4 | ... | 1 | 4·0 | 7·6 | ·082 | L. |
| | | 223·5 | 5·40 | 1 | ... | | ·753 | B. |
| 49 | 71 22 | 319·6 | 0·45 | 2 | 6·0 | 6·4 | ·896 | W.B. |
| 49 | 66 55 | 21·5 | 0·91 | 4 | 6·2 | 6·8 | ·622 | W.B. |
| 51 | 30 11 | 324·3 | 0·11 | 2 | 6·2 | 6·2 | ·436 | B. |
| 53 | 69 9 | 106·0 | 0·56 | 3 | 6·8 | 8·0 | ·300 | W.B. |
| 0 | 77 13 | 276·8 | 0·64 | 2 | 8·3 | 8·9 | ·896 | W.B. |
| 4 | 66 44 | 286·3 | 0·60 | 1 | 7·2 | 7·2 | ·025 | W.B. |
| 5 | 39 30 | 93·9 | 0·64 | 1 | 7·0 | 7·5 | ·118 | B. |
| 15 | 91 2 | 352·4 | 1·56 | 1 | 6·2 | 7·2 | ·830 | B. |
| 18 | 79 9 | 66 9 | 0·33 | 1 | 7·8 | 8·8 | ·830 | B. |
| 22 | 85 10 | 157·7 | 0·26 | 1 | 6·7 | 7·0 | ·830 | B. |
| 26 | 75 10 | 16·4 | 1·25 | 1 | 4·0 | 10·5 | ·865 | L. |
| 41 | 57 20 | 261·4 | 1·95 | 2 | 8·3 | 8·8 | ·032 | W.B. |
| 38 | 80 56 | 253·2 | 0·65 | 1 | 8·4 | 8·7 | ·830 | B. |
| 42 | 57 25 | 22·7 | 0·47 | 1 | 8·7 | 8·7 | ·923 | W.B. |
| 46 | 45 38 | 176·1 | 0·36 | 3 | 7·5 | 7·5 | ·923 | W.B. |
| 49 | 61 41 | 354·6 | 0·38 | 4 | 7·5 | 8·2 | ·499 | W.B. |
| ... | | 163·5 | 5·42 | 2 | 7·5 | 8·9 | ·940 | W.B. |

| Star's Name. | R.A. 1900. h m | N.P.D. 1900. ° ′ | Position Angle. ° | Distance. ″ | No. of Nights. | Mags. | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|---|
| Σ 346 ... ... | 2 59 | 65 8 | 94·1 | 0·49 | 2 | 6·0 6·0 | ·040 | W.B. |
| | | | 94·0 | 0·43 | 1 | ... | ·808 | B. |
| * ... ... | 2 59 | 65 9 | 166·6 | 1·93 | 1 | ... | ·913 | L. |
| β 83 ... ... | 2 41 | 95 23 | 103·3 | 0·92 | 1 | 7·9 9·4 | ·830 | B. |
| β 1030 ... | 3 4 | 68 39 | 155·2 | 0·49 | 1 | 8·5 8·5 | ·077 | W.B. |
| | | | 164·6 | 0·56 | 2 | ... | ·524 | B. |
| | | | 159·3 | 0·49 | 1 | ... | ·986 | L. |
| β 530 ... ... | 3 8 | 67 25 | 188·6 | 1·77 | 1 | 9·7 10·1 | ·986 | L. |
| β 84 ... ... | 3 11 | 96 17 | 27·4 | 0·75 | 1 | 6·8 7·3 | ·830 | B. |
| OΣ 53 ... | 3 11 | 51 44 | 232·0 | 0·54 | 1 | 7·2 8·0 | ·923 | W.B. |
| β 878 ... ... | 3 23 | 67 32 | 75·0 | 1·37 | 1 | 5·8 13·0 | ·986 | L. |
| Σ 412 ... ... | 3 29 | 65 52 | 19·9 | 0·30 | 1 | 6·6 6·9 | ·077 | W.B. |
| | | | 6·6 | 0·24 | 3 | ... | ·622 | B. |
| β 533 ... ... | 3 29 | 58 39 | 44·3 | 0·48 | 2 | 8·0 8·0 | ·058 | W.B. |
| | | | 53·3 | 0·49 | 1 | ... | ·808 | B. |
| Σ 425 ... ... | 3 33 | 56 10 | 268·3 | 2·37 | 2 | 7·3 7·3 | ·021 | W.B. |
| β 536 ... ... | 3 40 | 66 6 | 293·2 | 0·19 | 1 | 8·2 8·7 | ·939 | B. |
| | | | 319·2 | 0·30 | 1 | ... | ·986 | L. |
| β 538 ... ... | 3 42 | 66 12 | 135·2 | 2·06 | 1 | 10·0 10·5 | ·986 | L. |
| β 1184... ... | 3 42 | 67 56 | 272·6 | 0·39 | 1 | 8·0 8·5 | ·923 | W.B. |
| | | | 271·3 | 0·58 | 1 | ... | ·939 | B. |
| OΣ 516 ... | 3 44 | 58 1 | 42·4 | 2·09 | 1 | 7·2 9·2 | ·923 | W.B. |
| OΣ 531 ... | 4 1 | 52 12 | 129·8 | 1·99 | 1 | 8·5 10·2 | ·112 | W.B. |
| Ho. 326 ... | 4 3 | 61 37 | 180·8 | 0·32 | 1 | 8·5 8·5 | ·939 | B. |
| OΣ 77 ... ... | 4 10 | 58 33 | 178·0 | 0·22 | 1 | 7·5 7·5 | ·118 | B. |
| OΣ 80 ... ... | 4 16 | 47 49 | 183·2 | 0·45 | 1 | 6·5 7·0 | ·112 | W.B. |
| | | | 180·1 | 0·51 | 2 | ... | ·452 | B. |
| OΣ 74 ... ... | 4 7 | 80 36 | 288·4 | 0·36 | 1 | 8·0 8·5 | ·939 | B. |
| Σ 535 ... ... | 4 18 | 78 51 | 320·2 | 1·70 | 2 | 6·7 8·2 | ·517 | W.B. |
| Aldebaran ... | 4 30 | 73 42 | 110·0 | 30·54 | 1 | 1 13·5 | ·036 | L. |
| OΣ 86 ... ... | 4 31 | 70 27 | 44·6 | 0·53 | 1 | 7·5 7·5 | ·099 | L. |
| | | | 61·3 | 0·43 | 3 | ... | ·667 | W.B. |
| | | | 55·3 | 0·43 | 1 | ... | ·118 | B. |
| * ... ... ... | 4 30 | 70 15 | 190·4 | 0·39 | 1 | 7·5 8·0 | ·099 | L. |
| | | | 192·1 | 0·41 | 1 | ... | ·121 | W.B. |
| Σ 567 ... ... | 4 31 | 70 43 | 319·1 | 1·70 | 1 | 8·5 9·0 | ·099 | L. |
| | | | 318·5 | 1·82 | 2 | ... | ·099 | W.B. |
| Σ 572 ... ... | 4 32 | 63 18 | 22·0 | 3·81 | 1 | 6·5 6·5 | ·077 | W.B. |

| R.A. 1900. | N.P.D. 1900. | Position Angle. | Distance. | No. of Nights. | Mags. | | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|---|
| m | ° ′ | ° | ″ | | | | | |
| 46 | 79 6 | 68·8 | 0·38 | 3 | 7·5 | 7·8 | ·612 | L. |
| | | 64·2 | 0·26 | 3 | | ... | ·384 | B. |
| | | 59·7 | 0·31 | 2 | | ... | ·117 | W.B. |
| | ... | 156·0 | 18·10 | 1 | 7·5 | 13·0 | ·099 | L. |
| 3 | 62 5 | 48·6 | 0·26 | 1 | 7·2 | 8·8 | ·246 | L. |
| | ... | 27·3 | 11·62 | 1 | 7·2 | 9·2 | ·246 | L. |
| 6 | 91 54 | 25·1 | 0·56 | 1 | 8·3 | 8·4 | ·118 | B. |
| 10 | 98 19 | 179·3 | 0·36 | 1 | 8 | 8 | ·036 | L. |
| | ... | 201·7 | 9·70 | 1 | 1 | 8 | ·036 | L. |
| 19 | 92 29 | 79·8 | 1·08 | 1 | 3·5 | 5·5 | ·085 | B. |
| 21 | 55 40 | 220·7 | 1·02 | 1 | 8·5 | 8·8 | ·246 | L. |
| | ... | 98·3 | 3·62 | 1 | | 14·0 | ·246 | L. |
| | ... | 108·6 | 12·58 | 1 | | 13·8 | ·246 | L. |
| | ... | 131·6 | 18·40 | 1 | | 9·4 | ·246 | L. |
| | ... | 189·3 | 27·78 | 1 | | 10·1 | ·246 | L. |
| 31 | 63 8 | 168·8 | 0·74 | 2 | 7·1 | 7·2 | ·137 | W.B. |
| 32 | 59 34 | 336·4 | 0·22 | 2 | 5·6 | 6·0 | ·124 | B. |
| | | 331·1 | 0·18 | 2 | | ... | ·281 | L. |
| | ... | 267·4 | 12·24 | 1 | 5·6 | 8·7 | ·268 | L. |
| 33 | 52 6 | 73·6 | 0·61 | 1 | 7·5 | 7·5 | ·151 | B. |

| Star's Name. | R.A. 1900. | N.P.D. 1900. | Position Angle. | Distance. | No. of Nights. | Mags. | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | ° | ″ | | | | |
| Σ 1066 ... | 7 14 | 67 50 | 211·0 | 7″44 | 1 | 3·2 8·2 | ·233 | W.B. |
| β 579 ... ... | 7 27 | 56 40 | 28·7 | 0·96 | 1 | 8·0 10·5 | ·323 | L. |
| Σ 1110 ... (Castor) | 7 28 | 57 54 | 226·0 | 5·62 | 1 | 2·7 3·7 | ·044 | L. |
| | | | 223·6 | 5·75 | 2 | ... | ·154 | W.B. |
| OΣ 175 ... | 7 28 | 58 49 | 338·4 | 0·75 | 2 | 6·0 6·6 | ·174 | B. |
| | | | 332·6 | 0·63 | 2 | ... | ·230 | W.B. |
| | | | 329·9 | 0·61 | 1 | ... | ·323 | L. |
| OΣ 177 ... | 7 35 | 52 20 | 127·6 | 0·61 | 1 | 7·5 8·5 | ·233 | W.B. |
| | | | 122·7 | 0·58 | 2 | ... | ·388 | B. |
| | | | 125·9 | 0·56 | 2 | ... | ·308 | L. |
| β 580 ... ... (Pollux C.D) | 7 39 | 61 44 | 137·1 | 1·45 | 1 | 2·0 14·3 | ·312 | L. |
| β 101 ... ... | 7 47 | 103 38 | 302·7 | 0·48 | 1 | 5·2 6·5 | ·315 | B. |
| OΣ 185 ... | 7 52 | 88 36 | 24·1 | 0·26 | 1 | 6·8 7·0 | ·304 | B. |
| β 581 A.B. | 7 59 | 77 26 | 291·3 | 0·28 | 3 | 8·5 8·6 | ·195 | B. |
| | | | 282·0 | 0·68 | 1 | ... | ·312 | L. |
| A.C. | | ... | 200·0 | 5·57 | 1 | 11·0 | ·312 | L. |
| Σ 1184 ... | 8 3 | 51 49 | 340·8 | 27·37 | 1 | 8·0 8·5 | ·227 | W.B. |
| | | | 341·0 | 26·97 | 1 | ... | ·293 | L. |
| Σ 1186 ... | 8 3 | 62 13 | 220·6 | 3·51 | 1 | 7·1 10·4 | ·293 | L. |
| Σ 1187 ... | 8 3 | 57 28 | 43·1 | 2·37 | 3 | 7·1 8·0 | ·256 | W.B. |
| Σ 1196 A.B. ζ Cancri | 8 6 | 72 3 | 5·6 | 0·84 | 1 | 5·0 5·7 | ·176 | L. |
| | | | 2·2 | 1·08 | 2 | ... | ·270 | W.B. |
| A.C. | | ... | 113·0 | 5·44 | 1 | 5·0 6·5 | ·176 | L. |
| | | | 114·3 | 5·51 | 2 | ... | ·270 | W.B. |
| B.C. | | ... | 124·1 | 6·12 | 1 | 5·7 6·5 | ·176 | L. |
| | | | 126·3 | 6·20 | 2 | ... | ·270 | W.B. |
| Σ 1202 ... | 8 8 | 78 51 | 318·2 | 2·43 | 1 | 7·7 9·8 | ·296 | W.B. |
| β 1244 ... | 8 9 | 87 43 | 43·8 | 0·70 | 2 | 7·9 8·1 | ·239 | B. |
| Σ 1211 ... | 8 12 | 50 42 | 133·3 | 1·17 | 1 | 8·7 9·2 | ·233 | W.B. |
| Σ 1216 ... | 8 16 | 91 17 | 202·0 | 0·47 | 1 | 7·5 8·2 | ·304 | B. |
| β 585 ... ... | 8 36 | 69 10 | 111·4 | 0·41 | 1 | 7·5 9·0 | ·255 | W.B. |
| | | | 116·7 | 0·37 | 2 | ... | ·315 | B. |
| β 209 ... ... | 8 37 | 50 50 | 357·8 | 1·72 | 1 | 8·2 8·7 | ·233 | W.B. |
| Σ 1273 ... ε Hydræ A.C. | 8 41 | 83 13 | 232·3 | 3·51 | 2 | 3·5 7·7 | ·269 | L. |
| Schiaparelli A.B. | | ... | 280·6 | 0·11 | 2 | 3·5 6·0 | ·284 | L. |
| | | | 272·3 | 0·18 | 3 | ... | ·306 | B. |

| A. | N.P.D. 1900. | Position Angle. | Distance. | No. of Nights. | Mags. | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|
| h | ° ′ | ° | ″ | | | | |
| 4 | 80 46 | 172·7 | 0·45 | 1 | 7·7 8·8 | ·306 | L. |
| | | 178·9 | 0·36 | 1 | ... | ·315 | B. |
| 5 | 81 21 | 43·9 | 3·06 | 1 | ... | ·277 | W.B. |
| 6 | 81 17 | 338·5 | 0·71 | 2 | 7·5 8·7 | ·306 | B. |
| | | 349·7 | 0·53 | 1 | ... | ·306 | L. |
| 7 | 96 48 | 137·6 | 0·73 | 1 | 6·0 9·0 | ·315 | B. |
| 8 | 36 52 | 65·3 | 19·05 | 1 | 7·1 7·2 | ·298 | B. |
| 2 | 61 00 | 17·9 | 0·77 | 1 | 7·5 7·8 | ·085 | B. |
| | | 21·6 | 0·66 | 2 | ... | ·272 | W.B. |
| | | 20·6 | 0·84 | 1 | ... | ·294 | L. |
| 8 | 61 39 | 221·8 | 1·39 | 3 | 7·5 8·9 | ·287 | W.B. |
| | | 218·1 | 1·43 | 1 | ... | ·293 | L. |
| 9 | 63 2 | 200·6 | 2·58 | 1 | 5 10·5 | ·293 | L. |
| 9 | 63 33 | 17·6 | 3·40 | 1 | 9·5 10·0 | ·293 | L. |
| 9 | 83 14 | 319·9 | 1·86 | 2 | 7·5 7·6 | ·287 | W.B. |
| | | 319·9 | 1·98 | 1 | ... | ·290 | L. |
| 0 | 58 25 | 46·0 | 0·90 | 1 | 8·7 10·2 | ·323 | L. |
| 3 | 80 27 | 111·6 | 0·64 | 3 | 6·2 7·0 | ·291 | B. |
| | | 112·1 | ... | 1 | ... | ·361 | L. |
| 5 | 50 35 | 284·5 | ... | 1 | 7·0 8·3 | ·364 | W.B. |
| 4 | 73 55 | 182·4 | 1·10 | 1 | 8·5 10·7 | ·313 | L. |

| Star's Name. | R.A. 1900. | N.P.D. 1900. | Position Angle. | Distance. | No. of Nights. | Mags. | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | ° | ″ | | | | |
| OΣ 217 ... | 10 21 | 72 16 | 148·8 | 0·87 | 2 | 7·3 7·8 | ·222 | B. |
| | | | 145·1 | 0·88 | 3 | ... | ·310 | W.B. |
| OΣ 218 ... | 10 22 | 85 56 | 75·5 | 0·82 | 2 | 7·3 9·2 | ·321 | B. |
| Σ 1457 ... | 10 33 | 83 45 | 316·6 | 1·35 | 1 | 7·4 8·4 | ·296 | W.B. |
| | | | 314·1 | ... | 1 | ... | ·361 | L. |
| OΣ 224 ... | 10 34 | 80 38 | 296·5 | 0·39 | 2 | 7·2 9·2 | ·321 | B. |
| OΣ 225 A.B. | 10 35 | 70 14 | 243·3 | 0·92 | 2 | 7·5 11·2 | ·307 | L. |
| A.C. | | | 351·8 | 6·30 | 2 | 7·5 9·8 | ·307 | L. |
| OΣ 227 ... | 10 36 | 78 44 | 348·5 | 0·61 | 2 | 7·5 8·5 | ·293 | B. |
| | | | 345·2 | 0·65 | 2 | ... | ·306 | L. |
| OΣ 228 ... | 10 42 | 66 54 | 188·3 | 0·58 | 2 | 7·2 8·1 | ·222 | B. |
| | | | 185·2 | 0·41 | 1 | ... | ·288 | W.B. |
| | | | 191·9 | 0·57 | 2 | ... | ·318 | L. |
| OΣ 229 ... | 10 42 | 48 21 | 318·4 | 0·85 | 4 | 6·7 7·1 | ·256 | B. |
| β 915 ... ... | 10 44 | 65 11 | 230·1 | 1·57 | 1 | 9·0 9·2 | ·312 | L. |
| | | | 227·2 | 1·42 | 1 | ... | ·315 | B. |
| Ho. 378 ... | 10 59 | 51 2 | 225·3 | 0·48 | 3 | 8· 8·1 | ·289 | B. |
| Ho. 48... ... | 10 59 | 66 18 | 12·1 | 1·46 | 1 | 8·3 11 | ·236 | L. |
| Σ 1517 ... | 11 8 | 69 19 | 267·4 | 0·52 | 3 | 7·3 7·3 | ·233 | B. |
| | | | 265·8 | 0·44 | 1 | ... | ·312 | L. |
| | | | 272·5 | ... | 1 | ... | ·364 | W.B. |
| Σ 1523 ... | 11 13 | 57 54 | 147·5 | 2·29 | 1 | 4·0 4·9 | ·323 | L. |
| (ζ Ursæ Maj.) | | | 146·8 | 2·28 | 4 | ... | ·342 | W.B. |
| Σ 1527 ... | 11 14 | 75 11 | 16·6 | 3·01 | 2 | 6·9 3·1 | ·370 | W.B. |
| | | | 17·4 | 3·40 | 2 | ... | ·374 | L. |
| Σ 1536 ... | 11 19 | 78 55 | 55·7 | 2·43 | 2 | 3·9 7·1 | ·370 | W.B. |
| | | | 49·7 | 2·39 | 2 | ... | ·372 | L. |
| Lalande 21846 | 11 24 | 58 59 | 9·5 | 0·69 | 1 | 7 11 | ·288 | W.B. |
| | | | 8·8 | 0·92 | 3 | ... | ·290 | L. |
| OΣ 234 ... | 11 25 | 48 10 | 144·1 | 0·26 | 3 | 7·0 7·4 | ·352 | B. |
| | | | 137·9 | 0·27 | 1 | ... | ·504 | L. |
| OΣ 235 ... | 11 26 | 28 22 | 121·5 | 0·42 | 1 | 6·0 7·3 | ·501 | B. |
| | | | 124·7 | 0·47 | 1 | ... | ·504 | L. |
| Σ 1554 ... | 11 31 | 76 36 | 250·4 | 0·78 | 1 | 8·9 9·1 | ·315 | B. |
| | | | 251·9 | 0·96 | 1 | ... | ·383 | L. |
| Σ 1555 A.B. | 11 31 | 61 40 | 350·3 | 0·32 | 2 | 6·4 6·8 | ·272 | L. |
| | | | 352·1 | 0·39 | 4 | ... | ·301 | B. |
| Σ 1555 A.C. | 11 31 | 61 40 | 146·7 | 20·79 | 1 | 6·4 10·3 | ·288 | W.B. |

| A. 00. | N.P.D. 1900. | Position Angle. | Distance. | No. of Nights. | Mags. | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|
| m | ° ′ | ° | ″ | | | | |
| 34 | 48 18 | 263·4 | 1·20 | 1 | 7·4 9·0 | ·504 | L. |
| 52 | 49 6 | 249·0 | 1·48 | 1 | 8·2 10·2 | ·504 | L. |
| 6 | 49 33 | 331·3 | 0·97 | 1 | 6·3 7·0 | ·392 | B. |
| | | 330·3 | 0·97 | 2 | ... | ·510 | L. |
| 19 | 63 52 | 357·7 | 0·30 | 3 | 6·5 8·0 | ·289 | L. |
| | | 1·4 | 0·30 | 2 | ... | ·321 | B. |
| 22 | 62 25 | 39·8 | 2·12 | 2 | 8·3 8·6 | ·292 | W.B. |
| | | 41·0 | 1·98 | 3 | ... | ·360 | L. |
| 25 | 79 44 | 220·5 | 1·57 | 3 | 7·5 8·0 | ·345 | W.B. |
| | | 220·4 | 1·26 | 3 | ... | ·378 | L. |
| 30 | 78 3 | 237·0 | 2·65 | 1 | 8·5 8·5 | ·288 | W.B. |
| | | 237·1 | 2·51 | 2 | ... | ·386 | L. |
| 30 | 82 0 | 357·2 | 2·28 | 2 | 8 0 9·8 | ·386 | L. |
| 32 | 68 15 | 100·0 | 0·56 | 2 | 7·8 8·7 | ·292 | W.B. |
| | | 103·2 | 0·66 | 1 | ... | ·315 | B. |
| | | 105·5 | 0·67 | 2 | ... | ·386 | L. |
| 37 | 90 54 | 144·5 | 5·86 | 1 | 3·0 3·0 | ·375 | W.B. |
| 39 | 53 41 | 130·6 | 0·49 | 1 | 6·5 9·0 | ·236 | L. |
| 48 | 68 13 | 82·7 | 1·27 | 4 | 5·1 7·8 | ·364 | W.B. |
| | | 83·1 | 1·19 | 2 | ... | ·402 | L. |

| Star's Name. | R.A. 1900. | N.P.D. 1900. | Position Angle. | Distance. | No. of Nights. | Mags. | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | ° | ″ | | | | |
| OΣ 261 ... | 13 7 | 57 23 | 347·0 | 1·33 | 1 | 7·0 7·5 | ·390 | L. |
| | | | 343·0 | 1·52 | 3 | ... | ·434 | W.B. |
| β 800 ... ... | 13 12 | 72 27 | 117·6 | 2·66 | 2 | 7·1 10·2 | ·348 | L. |
| Σ 1734 ... | 13 16 | 86 32 | 188·5 | ... | 1 | 7·2 7·9 | ·367 | L. |
| Σ 1742 ... | 13 19 | 88 5 | 347·8 | ... | 1 | 7·4 7·9 | ·367 | L. |
| Ho. 260 ... | 13 19 | 60 15 | 323·6 | 0·78 | 2 | 8·3 8·5 | ·364 | L. |
| | | | 314·7 | ... | 1 | ... | ·326 | B. |
| | | | 316·2 | 0·78 | 1 | ... | ·419 | W.B. |
| OΣ 266 ... | 13 24 | 73 47 | 337·9 | 1·65 | 1 | 7·3 7·8 | ·375 | W.B. |
| | | | 391·8 | 1·92 | 2 | ... | ·385 | L. |
| OΣ 269 ... | 13 28 | 54 34 | 211·0 | 0·32 | 1 | 6·5 7·0 | ·392 | B. |
| | | | 218·0 | 0·38 | 1 | ... | ·422 | L. |
| | | | 219·4 | 0·27 | 2 | ... | ·430 | W.B. |
| Σ 1768 ... | 13 33 | 53 13 | 130·3 | 1·12 | 3 | 5·0 7·6 | ·448 | W.B. |
| | | | 130·6 | 0·89 | 1 | ... | ·534 | B. |
| β 612 ... ... | 13 35 | 78 45 | 230·4 | 0·30 | 1 | 6·3 6·5 | ·392 | B. |
| | | | 228·7 | 0·25 | 2 | ... | ·463 | W.B. |
| Σ 1785 ... | 13 45 | 62 31 | 285·0 | 1·26 | 2 | 7·2 7·5 | ·430 | W.B. |
| | | | 280·1 | 1·40 | 1 | ... | ·389 | L. |
| β 1270 ... | 13 59 | 81 2 | 15·1 | 0·31 | 1 | 8·2 8·3 | ·507 | W.B. |
| Σ 1808 ... | 14 6 | 62 56 | 255·3 | 2·73 | 1 | 8·0 9·0 | ·389 | L. |
| | | | 254·8 | 2·52 | 1 | ... | ·485 | W.B. |
| OΣ 278 ... | 14 8 | 45 21 | 88·6 | 0·31 | 2 | 7·5 7·5 | ·403 | B. |
| | | | 90·2 | 0·39 | 1 | ... | ·504 | L. |
| | | | 90·3 | 0·24 | 1 | ... | ·507 | W.B. |
| Σ 1819 ... | 14 10 | 86 24 | 177·5 | 1·33 | 1 | 7·9 8·0 | ·485 | W.B. |
| Σ 1820 ... | 14 10 | 34 13 | 254·5 | 2·00 | 1 | 8·2 8·5 | ·515 | L. |
| β 1272 A.B. | 14 14 | 40 47 | 136·1 | 1·31 | 3 | 8·4 9·5 | ·446 | L. |
| | | | 129·2 | 1·47 | 1 | ... | ·507 | W.B. |
| A.C. | | | 320·5 | 24·22 | 1 | 8·4 8·5 | ·504 | L. |
| β 1273... ... | 14 15 | 41 37 | 184·5 | 1·08 | 2 | 8·6 10·8 | ·332 | L. |
| Σ 1834 ... | 14 17 | 41 2 | 202·0 | 0·23 | 1 | 7·1 7·2 | ·159 | L. |
| | | | 179·0 | 0·1 | 1 | ... | ·504 | L. |
| | | | 219·4 | 0·18 | 3 | ... | ·311 | B. |
| Σ 1863 ... | 14 35 | 38 0 | 92·9 | 0·52 | 1 | 7·1 7·4 | ·507 | W.B. |
| | | | 89·4 | 0·69 | 1 | ... | ·515 | L. |
| Σ 1865 ... | 14 36 | 75 51 | 150·9 | 0·31 | 2 | 3·5 3·9 | ·348 | L. |
| | | | 151·8 | 0·36 | 4 | 3·5 3·9 | ·394 | B. |

| R.A. 1900. | N.P.D. 1900. | Position Angle. | Distance. | No. of Nights. | Mags. | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|
| h m | ° ′ | ° | ″ | | | | |
| 4 36 | 58 17 | 12·9 | 1·24 | 3 | 7·7 8·2 | ·452 | W.B. |
| 4 38 | 38 11 | 292·3 | 1·76 | 1 | 7·0 7·0 | ·507 | W.B. |
| | | 295·2 | 1·88 | 1 | ... | ·515 | L. |
| 4 41 | 62 30 | 321·7 | 2·85 | 1 | 3·0 6·3 | ·389 | L. |
| | | 327·6 | 2·67 | 1 | ... | ·419 | W.B. |
| 4 41 | 79 55 | 132·7 | 0·47 | 2 | 8·0 8·5 | ·478 | L. |
| 4 42 | 47 11 | 123·2 | 0·29 | 3 | 7·1 7·6 | ·346 | B. |
| | | 125·4 | 0·33 | 1 | ... | ·507 | W.B. |
| 4 44 | 83 37 | 243·8 | 0·52 | 2 | 7·0 7·0 | ·398 | B. |
| 4 47 | 70 29 | 201·4 | 2·77 | 2 | 5·1 7·4 | ·400 | L. |
| 4 48 | 44 40 | 321·7 | 0·70 | 4 | 7·5 7·6 | ·514 | B. |
| | | 322·3 | 0·83 | 1 | ... | ·507 | W.B. |
| 4 48 | 70 51 | 197·4 | 1·39 | 1 | 8·4 9·7 | ·411 | L. |
| | | 198·8 | 1·45 | 1 | ... | ·496 | W.B. |
| 4 49 | 73 53 | 194·4 | 1·58 | 1 | 6·5 7·0 | ·411 | L. |
| | | 191·3 | 1·67 | 2 | ... | ·491 | W.B. |
| 5 1 | 55 7 | 142·2 | 1·47 | 2 | 8·2 9·2 | ·491 | W.B. |
| 5 1 | 41 57 | 63·9 | 4·31 | 1 | 5·2 6·1 | ·518 | W.B. |
| 5 9 | 54 44 | 28·4 | 0·31 | 1 | 8 8 | ·304 | B. |
| | | 29·6 | 0·31 | 1 | ... | ·507 | W.B. |
| 5 14 | 62 48 | 224·4 | 0·60 | 2 | 5·5 6·0 | ·354 | B. |

| Star's Name. | B.A. 1900. | N.P.D. 1900. | Position Angle. | Distance. | No. of Nights. | Mags. | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | ° | ″ | | | | |
| β 619 ... ... | 15 39 | 76 1 | 8·0 | 0·39 | 2 | 6·5 7·0 | ·469 | B. |
| | | | 2·6 | 0·46 | 1 | ... | ·479 | L. |
| | | | 3·3 | 0·40 | 1 | ... | ·496 | W.B. |
| β 621 ... ... | 15 47 | 44 58 | 52·1 | 0·41 | 1 | 8·1 9·3 | ·507 | W.B. |
| | | | 56·5 | 0·43 | 1 | ... | ·731 | B. |
| Oʒ 303 ... | 15 56 | 76 27 | 149·0 | 0·84 | 1 | 7·0 8·0 | ·403 | B. |
| | | | 140·2 | 0·81 | 1 | ... | ·441 | W.B. |
| | | | 148·3 | 0·67 | 1 | ... | ·479 | L. |
| β 355 ... ... | 16 5 | 44 21 | 285·2 | 0·36 | 2 | 7·8 8·9 | ·704 | B. |
| ʒ 2021 ... | 16 9 | 76 12 | 153·0 | 3·98 | 1 | 6·7 6·9 | ·441 | W.B. |
| ʒ 2032 ... | 16 11 | 55 54 | 215·0 | 4·53 | 1 | 5·0 6·1 | ·687 | B. |
| β 951 ... ... | 16 20 | 56 23 | 51·0 | 0·91 | 1 | 8·1 9·0 | ·411 | L. |
| | | | 52·9 | 0·81 | 1 | ... | ·539 | W.B. |
| ʒ 2054 ... | 16 24 | 28 4 | 357·1 | 1·06 | ... | 5·7 6·9 | ·787 | B. |
| β 813 ... ... | 16 24 | 63 15 | 169·2 | 1·04 | 1 | 8·5 8·5 | ·523 | L. |
| | | | 169·9 | 1·01 | 1 | ... | ·594 | W.B. |
| | | | 163·1 | 1·09 | 1 | ... | ·676 | B. |
| β 814 ... ... | 16 24 | 49 53 | 322·4 | 0·34 | 2 | 8·4 8·7 | ·704 | B. |
| ʒ 2052 ... | 16 25 | 71 23 | 94·4 | 1·66 | 3 | 7·5 7·5 | ·492 | W.B. |
| | | | 96·0 | 1·83 | 1 | ... | ·556 | L. |
| ʒ 2055 ... | 16 26 | 87 48 | 57·8 | 1·04 | 1 | 4·0 6·1 | ·545 | B. |
| ʒ 3105 ... | 16 26 | 96 49 | 30·8 | 0·44 | 2 | 7·5 7·5 | ·469 | B. |
| β 817 ... ... | 16 28 | 66 33 | 144·3 | 1·05 | 1 | 8·2 8·2 | ·523 | L. |
| | | | 147·8 | 1·21 | 1 | ... | ·676 | B. |
| ʒ 2084 ... (ζ Herculis) | 16 38 | 58 13 | 231·5 | 0·84 | 2 | 3·0 6·5 | ·364 | L. |
| | | | 222·3 | 0·99 | 5 | ... | ·529 | L. |
| | | | 221·0 | 1·08 | 4 | ... | ·684 | L. |
| | | | 228·7 | 0·67 | 3 | ... | ·479 | B. |
| | | | 227·3 | 0·82 | 2 | ... | ·665 | B. |
| | | | 225·4 | 0·90 | 2 | ... | ·786 | B. |
| | | | 224·4 | 0·93 | 4 | ... | ·586 | W.B. |
| ʒ 2091 ... | 16 39 | 48 37 | 307·0 | 1·07 | 2 | 7·5 8·0 | ·575 | W.B. |
| | | | 305·8 | 1·04 | 2 | ... | ·682 | B. |
| De. 15... ... | 16 41 | 46 20 | 321·8 | 0·54 | 2 | 8·2 8·6 | ·704 | L. |
| | | | 315·0 | 0·48 | 1 | ... | ·731 | B. |
| Oʒ 315 ... | 16 46 | 88 37 | 158·5 | 0·67 | 1 | 6·2 8·1 | ·545 | B. |
| β 821 ... ... | 16 48 | 57 59 | 315·5 | 1·41 | 1 | 8·4 8·9 | ·643 | W.B. |
| | | | 309·5 | 1·38 | 2 | ... | ·676 | L. |

| R.A. 1900. | | N.P.D. 1900. | | Position Angle. | Distance. | No. of Nights. | Mags. | | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|---|---|---|
| h | m | ° | ′ | ° | ″ | | | | | |
| 16 | 48 | 61 | 10 | 332·6 | 0·36 | 2 | 6·7 | 8·5 | ·676 | L. |
| 16 | 54 | 85 | 53 | 93·4 | 1·45 | 1 | 8·5 | 8·5 | ·545 | B. |
| 16 | 56 | 24 | 49 | 95·5 | 0·15 | 3 | 5·5 | 6·5 | ·625 | B. |
| 16 | 57 | 81 | 24 | 159·5 | 1·35 | 1 | 6·2 | 7·4 | ·496 | W.B. |
| | | | | 160·2 | 1·16 | 1 | ... | | ·545 | B. |
| 17 | 1 | 79 | 19 | 299·3 | 1·02 | 1 | 8·4 | 9·4 | ·712 | L. |
| 17 | 3 | 35 | 24 | 145·5 | 2·27 | 1 | 5·0 | 5·1 | ·797 | B. |
| 17 | 5 | 105 | 36 | 251·0 | 0·33 | 3 | 3·4 | 3·9 | ·571 | B. |
| 17 | 10 | 75 | 30 | 112·1 | 4·87 | 1 | 3·0 | 6·1 | ·718 | W.B. |
| 17 | 12 | 63 | 17 | 56·6 | 0·52 | 1 | 8·3 | 8·9 | ·411 | L. |
| | | | | 45·7 | 0·63 | 1 | ... | | ·657 | L. |
| 17 | 12 | 33 | 46 | 313·0 | 0·20 | 1 | 7·6 | 8·0 | ·797 | B. |
| 17 | 15 | 57 | 14 | 346·7 | 0·57 | 1 | 9·0 | 9·5 | ·427 | L. |
| 17 | 15 | 57 | 14 | 344·1 | 1·15 | 1 | 8·4 | 8·7 | ·427 | L. |
| 17 | 17 | 57 | 40 | 227·3 | 1·58 | 1 | 8·5 | 9·6 | ·427 | L. |
| 17 | 20 | 47 | 47 | 90·7 | 1·64 | 2 | 9·2 | 9·2 | ·433 | L. |
| 17 | 21 | 36 | 3 | 81·6 | 0·47 | 1 | 8·8 | 8·9 | ·433 | L. |
| 17 | 21 | 59 | 9 | 70·2 | 1·75 | 2 | 9·4 | 9·5 | ·433 | L. |
| 17 | 25 | 90 | 59 | 327·7 | 0·94 | 4 | 6·0 | 6·3 | ·627 | B. |

| Star's Name. | R.A. 1900. | N.P.D. 1900. | Position Angle. | Distance. | No. of Nights. | Magn. | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | ° | ″ | | | | |
| A.C. 9... ... | 17 50 | 60 10 | 55·8 | 1·01 | 3 | 8·4 8·7 | ·552 | W.B. |
| | | | 55·8 | 1·10 | 1 | ... | ·731 | B. |
| Σ 2262 ... | 17 57 | 98 11 | 258·6 | 1·93 | 1 | 5·0 5·7 | ·687 | B. |
| Σ 2272 ... 70 Ophiuchi | 18 0 | 87 28 | 227·5 | 1·58 | 10 | 4·3 6·3 | ·598 | W.B. |
| Σ 2275 ... | 18 0 | 50 39 | 133·1 | 0·66 | 3 | 9·0 9·2 | ·466 | L. |
| OΣ 341 ... | 18 1 | 68 34 | 88·3 | 0·49 | 1 | 6·4 7·7 | ·559 | L. |
| | | | 86·2 | 0·30 | 3 | ... | ·654 | B. |
| A.C. 15 ... | 18 3 | 59 27 | 319·6 | 1·07 | 1 | 5·4 9·0 | ·482 | L. |
| Σ 2281 ... | 18 4 | 86 1 | 236·2 | 0·22 | 1 | 6·7 7·2 | ·633 | B. |
| Σ 2283 ... | 18 5 | 83 52 | 83·5 | 0·93 | 2 | 7·2 7·7 | ·540 | W.B. |
| Σ 2289 ... | 18 6 | 73 32 | 228·8 | 1·22 | 4 | 6·5 7·0 | ·563 | W.B. |
| Σ 2294 ... | 18 9 | 89 51 | 86·5 | 0·18 | 2 | 7·4 7·7 | ·660 | B. |
| β 1091 ... | 18 9 | 51 26 | 26·4 | 0·25 | 1 | 8·6 8·6 | ·731 | B. |
| β 641 ... ... | 18 18 | 68 32 | 339·8 | 0·84 | 2 | 7·5 9·0 | ·569 | W.B. |
| β 1203 ... | 18 18 | 89 15 | 71·2 | 0·24 | 2 | 7·5 7·7 | ·682 | B. |
| Σ 2315 ... | 18 21 | 62 40 | 193·1 | 0·34 | 4 | 7·5 9·0 | ·561 | L. |
| | | | 202·4 | 0·24 | 1 | ... | ·539 | W.B. |
| Ho. 84 ... | 18 20 | 62 40 | 319·5 | 4·08 | 3 | 9·0 10·0 | ·518 | L. |
| Σ 2318 ... | 18 21 | 64 4 | 254·1 | 20·75 | 1 | 7·9 10·0 | ·482 | L. |
| * ... ... | 18 22 | 64 2 | 138·8 | 1·50 | 1 | 9·5 10·0 | ·482 | L. |
| * ... ... | 18 23 | 64 2 | 263·7 | 2·94 | 1 | 9·5 10·0 | ·542 | L. |
| OΣ 351 ... | 18 23 | 41 18 | 23·7 | 0·59 | 2 | 8·0 8·3 | ·754 | B. |
| OΣ 543 ... | 18 23 | 43 10 | 133·4 | 1·08 | 2 | 7·2 9·2 | ·754 | B. |
| OΣ 357 ... | 18 31 | 78 21 | 239·3 | 0·39 | 1 | 7·5 7·6 | ·539 | W.B. |
| | | | 247·3 | 0·43 | 1 | ... | ·633 | B. |
| OΣ 358 ... | 18 31 | 73 6 | 193·0 | 1·87 | 3 | 6·8 7·2 | ·543 | W.B. |
| Σ 2356 ... | 18 34 | 61 23 | 60·4 | 0·89 | 2 | 8·2 8·6 | ·619 | L. |
| | | | 56·0 | 1·15 | 2 | ... | ·619 | W.B. |
| * ... ... | 18 34 | 61 18 | 253·4 | 1·11 | 1 | 9·0 10·0 | ·600 | W.B. |
| | | | 251·0 | 1·14 | 1 | ... | ·695 | L. |
| Ho. 87 ... | 18 34 | 73 34 | 103·0 | 0·45 | 1 | 7·8 8·1 | ·539 | W.B. |
| Ho. 437 A.B. | 18 37 | 58 27 | 120·9 | 0·30 | 2 | 8·3 8·5 | ·511 | L. |
| C.D. | ... | | 341·2 | 3·48 | 2 | 11·2 11·7 | ·511 | L. |
| Σ 2367 ... | 18 37 | 59 48 | 94·1 | 0·24 | 4 | 7·2 7·6 | ·568 | L. |
| | | | 76·0 | 0·23 | 1 | ... | ·631 | B. |
| Σ 2369 ... | 18 39 | 87 29 | 96·8 | 0·97 | 1 | 7·5 8·0 | ·687 | B. |
| Σ 2375 ... | 18 41 | 84 36 | 113·7 | 2·37 | 2 | 6·2 6·6 | ·605 | W.B. |

| R.A. 1900. | | N.P.D. 1900. | | Position Angle. | Distance. | No. of Nights. | Mags. | | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|---|---|---|
| h | m | ° | ′ | ° | ″ | | | | | |
| 18 | 44 | 73 | 51 | 182·9 | 1·88 | 1 | 8·0 | 10·6 | ·745 | L. |
| | | ... | | 187·8 | 3·08 | 1 | 8·0 | 11·0 | ·745 | L. |
| 18 | 45 | 79 | 26 | 207·2 | 0·84 | 1 | 8·0 | 8·4 | ·638 | W.B. |
| 18 | 45 | 78 | 36 | 226·3 | 1·30 | 1 | 7·7 | 9·3 | ·742 | L. |
| 18 | 47 | 78 | 19 | 4·3 | 0·19 | 1 | 8·7 | 9·1 | ·745 | L. |
| 18 | 53 | 57 | 14 | 220·0 | 1·11 | 2 | 6·0 | 9·5 | ·608 | L. |
| 18 | 53 | 64 | 2 | 95·9 | 0·91 | 3 | 7·6 | 7·7 | ·614 | W.B. |
| 18 | 54 | 76 | 31 | 264·6 | 16·68 | 1 | 5·7 | 9·2 | ·745 | L. |
| 18 | 55 | 57 | 40 | 5·1 | 1·54 | 1 | 8·5 | 10·7 | ·673 | L. |
| 18 | 57 | 70 | 58 | 65·4 | 0·77 | 3 | 7·8 | 8·2 | ·627 | W.B. |
| 19 | 1 | 76 | 17 | 63·4 | 5·76 | 1 | 3 | 13·0 | ·742 | L. |
| 19 | 2 | 59 | 43 | 247·0 | 0·69 | 1 | 8·0 | 9·2 | ·643 | W.B. |
| 19 | 3 | 67 | 59 | 80·0 | 3·43 | 2 | 7·2 | 8·3 | ·619 | W.B. |
| 19 | 4 | 63 | 4 | 145·8 | 0·24 | 1 | 8 | 8 | ·841 | B. |
| 19 | 7 | 87 | 33 | 195·4 | 0·35 | 2 | 7·7 | 8·5 | ·709 | B. |
| 19 | 11 | 70 | 9 | 325·7 | 1·50 | 1 | 8·5 | 9·7 | ·638 | W.B. |
| 19 | 12 | 74 | 1 | 216·1 | 0·96 | 2 | 7·3 | 8·5 | ·619 | W.B. |
| 19 | 12 | 62 | 43 | 158·7 | 0·83 | 2 | 7 | 7 | ·628 | B. |
| | | | | 150·8 | 0·84 | 2 | ... | | ·641 | W.B. |
| 19 | 14 | 83 | 51 | 39·2 | 0·71 | 3 | 8·2 | 8·3 | ·698 | B. |

| Star's Name. | R.A. 1900. | N.P.D. 1900. | Position Angle. | Distance. | No. of Nights. | Mags. | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | ° | ″ | | | | |
| Σ 2620 ... | 19 59 | 78 30 | 291·1 | 1·78 | 2 | 8·2 9·3 | ·742 | W.B. |
| Σ 2624 ... | 20 0 | 54 15 | 173·2 | 1·76 | 1 | 7·2 7·8 | ·715 | W.B. |
| β 57 ... ... | 20 1 | 74 47 | 118·0 | 2·37 | 1 | 6·7 11·3 | ·745 | L. |
| Σ 2695 ... | 20 28 | 64 32 | 80·6 | 1·11 | 1 | 6·2 8·0 | ·580 | L. |
| | | | 81·8 | 1·19 | 2 | ... | ·641 | W.B. |
| β 670 ... ... | 20 28 | 76 24 | 39·3 | 0·51 | 2 | 8·5 8·9 | ·717 | L. |
| * ... ... ... | 20 28 | 76 23 | 140·7 | 0·43 | 2 | 9·0 9·5 | ·717 | L. |
| β 151 ... A.B. (β Delphini) | 20 33 | 75 45 | 14·0 | 0·54 | 3 | 4·5 6·0 | ·634 | L. |
| | | | 16·8 | 0·45 | 8 | ... | ·681 | B. |
| | | | 14·6 | 0·39 | 2 | ... | ·641 | W.B. |
| A.C. | ... | | 119·1 | 25·11 | 1 | ... | ·832 | L. |
| A.D. | ... | | 330·3 | 37·80 | 1 | ... | ·832 | L. |
| Σ 2729 ... | 20 46 | 96 0 | 234·0 | 0·26 | 2 | 5·9 7·2 | ·694 | B. |
| β 367 ... ... | 20 51 | 62 28 | 133·3 | 0·40 | 1 | 8·0 6·0 | ·772 | L. |
| Σ 2737 ... | 20 54 | 86 5 | 285·3 | 0·62 | 4 | 5·7 8·6 | ·707 | B. |
| OΣ 424 ... | 20 55 | 74 49 | 313·1 | 0·42 | 1 | 7·5 8·7 | ·580 | L. |
| | | | 321·2 | 0·43 | 2 | ... | ·742 | B. |
| β 69 ... ... | 20 58 | 68 46 | 315·2 | 0·82 | 1 | 8·3 9·1 | ·580 | L. |
| Σ 2744 ... | 20 58 | 88 52 | 163·0 | 1·37 | 3 | 6·3 7·0 | ·717 | B. |
| Σ 2749...A.B. | 21 0 | 86 51 | 155·2 | 4·13 | 1 | 7·7 8·9 | ·772 | L. |
| A.D. | ... | ... | 153·2 | ... | 1 | 7·7 8·9 | ·772 | L. |
| Secchi ...B.C. | ... | ... | 334·8 | 0·88 | 1 | 8·9 10·0 | ·772 | L. |
| OΣ 527 ... | 21 3 | 85 15 | 267·4 | 0·29 | 2 | 6·5 8·6 | ·709 | B. |
| γ Equulei ... | 21 5 | 80 16 | 273·3 | 2·33 | 1 | 5·0 11·5 | ·559 | L. |
| Ho. 152 ... | 21 8 | 62 4 | 326·5 | 0·43 | 3 | 8·5 9·5 | ·869 | W.B. |
| OΣ 535 ... (δ Equulei) | 21 10 | 80 24 | 196·2 | 0·22 | 1 | 4·1 4·1 | ·534 | B. |
| | | | 196·3 | 0·21 | 1 | ... | ·622 | B. |
| | | | 179·0 | 0·24 | 1 | ... | ·654 | B. |
| | | | 71·7 | 0·08 | 1 | ... | ·687 | B. |
| | | | 69·3 | 0·11 | 1 | ... | ·701 | B. |
| | | | 64·1 | 0·11 | 1 | ... | ·731 | B. |
| | | | 66·3 | 0·05 | 1 | ... | ·753 | B. |
| | | | 64·5 | 0·09 | 1 | ... | ·764 | B. |
| | | | 54·4 | 0·06 | 1 | ... | ·797 | B. |
| | | | 55·1 | 0·11 | 1 | ... | ·830 | B. |
| | | | 50·8 | 0·12 | 1 | ... | ·841 | B. |
| OΣ 535 ... | 21 10 | 80 24 | 185·0 | 0·21 | 1 | ... | ·543 | L. |

| R.A. 1900. | N.P.D. 1900. | Position Angle. | Distance. | No. of Nights. | Mags. | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|
| h m | o ′ | ° | ″ | | | | |
| ... | ... | 193·1 | 0·27 | 1 | ... | ·559 | L. |
| | | 193·9 | 0·22 | 1 | ... | ·577 | L. |
| | | 161·2 | ... | 1 | ... | ·696 | L. |
| | | 210·3 | <0·1 | 1 | ... | ·746 | L. |
| | | 210·6 | <0·1 | 1 | ... | ·776 | L. |
| | | 185·0 | <0 1 | 1 | ... | ·860 | L. |
| | | 196·5 | <0·1 | 1 | ... | ·865 | L. |
| | | 203·0 | <0·1 | 1 | ... | ·959 | L. |
| 21 16 | 87 18 | 100·2 | 1·42 | 2 | 7·8 9·5 | ·742 | B. |
| 21 24 | 79 21 | 298·0 | 1·47 | 2 | 7·0 7·0 | ·842 | W.B. |
| 21 28 | 69 44 | 332·2 | 2·75 | 2 | 7·3 8·0 | ·853 | W.B. |
| 21 34 | 90 30 | 274·1 | 0·47 | 3 | 6·5 6·9 | ·738 | B. |
| 21 40 | 61 42 | 122·1 | 2·60 | 1 | 4·0 5·0 | ·868 | L. |
| 21 40 | 62 38 | 96·0 | 0·32 | 2 | 7·5 7·5 | ·690 | L. |
| | | 90·6 | 0·34 | 1 | ... | ·534 | B. |
| 21 40 | 64 49 | 243·2 | 0·11 | 1 | 3·9 5·0 | ·008 | L. |
| | | 236·2 | 0·14 | 1 | ... | ·036 | L. |
| | | 210·3 | 0·11 | 1 | ... | ·515 | L. |
| | | 185·4 | 0·10 | 1 | ... | ·542 | L. |
| | | 194·2 | 0·12 | 1 | ... | ·559 | L. |
| | | 101·7 | 0·10 | 1 | | ·626 | L. |

| Star's Name. | R.A. 1900. | N.P.D. 1900. | Position Angle. | Distance. | No. of Nights. | Mags. | | Epoch 1901. | Obs. |
|---|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | ° | ″ | | | | | |
| Σ 2944 ... | 22 43 | 94 44 | 260·1 | 3·41 | 2 | 7·0 | 7·5 | ·781 | B. |
| OΣ 483 ... | 22 54 | 78 48 | 222·3 | 0·94 | 2 | 6·2 | 7·7 | ·842 | W.B. |
| β 79 ... ... | 23 12 | 92 4 | 87·1 | 1·03 | 3 | 8·0 | 8·6 | ·786 | B. |
| β 80 ... ... | 23 14 | 85 8 | 19·6 | 0·23 | 3 | 8·0 | 8·8 | ·786 | B. |
| β 1222 ... | 23 23 | 86 59 | 38·0 | 1·20 | 2 | 9 | 9 | ·814 | B. |
| β 1266 ... | 23 25 | 59 44 | 14·3 | 0·22 | 4 | 8·9 | 9·0 | ·664 | L. |
| β 720 ... ... | 23 28 | 59 14 | 342·3 | 0·32 | 3 | 5·9 | 6·0 | ·563 | L. |
| | | | 335·5 | 0·30 | 3 | | ... | ·859 | B. |
| β 858 ... ... | 23 36 | 58 0 | 261·6 | 0·54 | 4 | 8·0 | 8·2 | ·669 | L. |
| A. G. C. 14... | 23 39 | 61 2 | 200·4 | 1·40 | 2 | 5·0 | 9·5 | ·941 | L. |
| Barnard ... | 23 42 | 85 19 | 170·0 | 0·60 | 1 | 8·6 | 8·6 | ·797 | B. |
| Σ 3050 ... | 23 54 | 56 50 | 214·4 | 2·55 | 2 | 6·0 | 6·0 | ·886 | W.B. |
| β 733 ... ... | 23 57 | 63 26 | 239·6 | 0·66 | 3 | 6·0 | 11·0 | ·592 | L. |
| Σ 3056 ... | 23 59 | 56 17 | 142·6 | 0·57 | 1 | 7 | 8 | ·044 | L. |
| | | | 145·3 | 0·53 | 2 | | ... | ·792 | B. |
| β 862 ... ... | 23 59 | 52 23 | 314·3 | 0·58 | 1 | 8·5 | 9·0 | ·044 | L. |

## *Capella.*

*Observer* ... ... ... ... **Mr. Lewis.**

| Date 1901. G.M.T. | Hour Angle. | Day from Beginning of the Year. | Position Angle. | Remarks. |
|---|---|---|---|---|
| d h | | | ° ′ | |
| Jan. 4 7½ | 3½E. | 3·3 | 36 8 | Powers 670 and 1120. Observed without blue shade. Undoubtedly elongated, and quite as distinct as κ Pegasi—better definition here. Star surrounded by some fifteen rings. Measures of distance were made to verify the elongation. The diameter of the star was measured first in the direction of apparent elongation, and then at right angles to this direction, the measures being made by placing the inside edges of the wires tangential to the disc.<br>(1) Sum of direct readings, 0″·138. Sum of reverse readings, 0″·115. ½ (difference), 0″·0115.<br>(2) Sum of direct readings, 0·135. Sum of reverse readings, 0·125. ½ (difference), 0″·0050.<br>If the discs are assumed equal, then the separation of centres is 0″·0065 = 0″·076. |

| Hour Angle. | Day from Beginning of the Year. | Position Angle. | Remarks. |
|---|---|---|---|
| | | ° ′ | |
| E. | 13·3 | 17 1 | Powers 670 and 1120. Images very fine. A large number of rings, easier than κ Pegasi; but the definition was better when measuring Capella than it was when measuring κ Pegasi. Measures made in the same way as on January 4.<br>(1) Sum of direct readings, 0″·174.<br>Sum of reverse readings, 0″·093.<br>½ (difference), 0″·041.<br>(2) Sum of direct readings, 0″·164.<br>Sum of reverse readings, 0″·094.<br>½ (difference), 0″·035.<br>If the discs are assumed equal, then the separation of centres is 0″·096 = 0″·072.<br>κ Pegasi measured in the same way gave 0″·108.<br>Both Capella and κ Pegasi were measured in the usual way by trying to make the centres of the wires tangential to the discs; the results were:<br>0″·132 for Capella.<br>0″·137 for κ Pegasi. |
| ½W. | 84·3 | 285 7 or 105 7 | Power 670. Elongation not so apparent as on January 14. |
| ½W. | 90·3 | | Power 670. Definition very fine. A large number of rings; as nearly |

| Date 1901. G.M.T. | | Hour Angle. | Day from Beginning of the Year. | Position Angle. | Remarks. |
|---|---|---|---|---|---|
| d | h | | | ° ′ | |
| Nov. 14 | 10½ | 3½E. | 317·4 | | Powers 670 and 1120. Star nucleus very small indeed and beautifully defined. A large number of rings almost perfect and circular. If the disc is not round the elongation is at 263°·2 or 83°·2. |
| | *Observer* | ... | ... | ... ... | Mr. Bryant. |
| Mar. 1 | 3 | 3¼E. | 59·1 | 207 25 | Power 670. Clouds passing. Very windy. Occasional glimpses of fine definition through thin clouds. Two blue shades used. |
| Apr. 17 | 6 | 2½W. | 106·3 | 30 48 | Power 670. Definition fine through thin cloud. Elongation very slight. |
| 20 | 0 | 3 E. | 109·0 | 28 25 | Power 670. Very windy. Sky very clear. Star very bright. Seeing at intervals excellent when wind dropped. Two blue shades used. With power 1120 effect of wind greater, preventing measures. |
| 22 | 5½ | 2½W. | 111·2 | 14 12 | Power 670. Definition fair. Star small and steady. Thin clouds. Elongation very slight. Two blue shades used. |
| 26 | 5½ | 2½W. | 115·2 | 359 5 | Power 670. Very windy. Definition fair momentarily. Clouds passing. |
| 30 | 5¼ | 3 W. | 119·2 | 344 55 | Powers 670 and 1120. Definition very fine indeed, but elongation very slight. Measures give distance about 0″·08 (power 1120). Distance thought to be really less than measures indicate. Two blue shades used. |
| May 24 | 5½ | 4½W. | 143·2 | 267 29 | Power 670. Very windy, otherwise definition at times good. Blue shades used. Too windy to use higher power. Measures of distance give 0″·09. |
| July 4 | 0½ | 2½W. | 184·0 | 135 25 | Power 670. Hazy. Image very unsteady, but small. Two blue shades used. |
| 11 | 0 | 2½W. | 191·0 | 112 51 | Power 670. Definition fair at long intervals. Sky hazy. Two blue shades used. Apparently this is the right quadrant. |
| Aug. 18 | 22 | 2¾W. | 229·9 | 326 40 | Power 670. Sky hazy. Definition fair. N.E. wind. Quadrant seems to be right. Used two shades or one or more as haze varied. |
| 19 | 21¾ | 2½W. | 230·9 | 322 42 | Power 670. Through cloud. Two blue shades used. Star very bright and diffused. Strong N.E. wind. |

| ur gle. | Day from Beginning of the Year. | Position Angle. | Remarks. |
|---|---|---|---|
| W. | 231·9 | 319° 32′ | Powers 670 and 1120. Thin cloud. Two blue shades used. Definition not very good. Star diffused, generally with moments of better seeing. Measures of distance give 0″·078. |
| W. | 232·9 | 316 0 | Powers 670 and 1120. Two blue shades used. Taken during lulls of wind. Definition at times very good. |
| W. | 243·9 | 279 27 | Powers 670 and 1120. Blue and green shades used. Through thin cloud. Definition varying. Measures of distance gave 0″·09. |
| | ... | ... | ... ... Mr. Bowyer. |
| E. | 1·3 | 45 3 | Powers 670 and 1120. Sky very hazy. Definition fair. Rings visible occasionally. Measures easier than December 29. |
| E. | 14·3 | 18 8 | Powers 670 and 1120. Measures made with and without blue shade. Definition fair. Several rings visible occasionally. Image rather diffused with high power. |
| E. | 17·3 | 11 0 | Powers 670 and 1120. Definition fair, but image unsteady. Measures made with and without blue shade. Elongation seemed rather more apparent. Measures easier than for ε Persei. |

difficult *comes* than any of these was suspected, and on January 28 and on subsequent nights it was seen and measured, but with great difficulty. The following are the previous results of the measures of this group, together with my own recent measures, which are, in general, the means of three nights' observations.

| | Epoch. | Position Angle. | Distance. | Observer. |
|---|---|---|---|---|
| | | ° | ″ | |
| AB (Espin) | 1902·09 | 257·0 | 5·43 | Espin. |
| AC (Σ 485) | 1830·24 | 303·32 | 17·98 | Σ. |
| | 1867·32 | 303·07 | 17·89 | De. |
| | 1902·09 | 303 30 | 17·45 | Espin. |
| CD (Demb.) | 1867·10 | 85·10 | ... | De. |
| | 1902·10 | 84·75 | 14·15 | Espin. |
| CE (Demb.) | 1867·68 | 333·65 | 19·86 | De. |
| | 1902·09 | 333·07 | 18·87 | Espin. |
| $A^1B^1$ (Σ 484) | 1830·87 | 132·42 | 5·42 | Σ. |
| | 1867·32 | 130·80 | 5·38 | De. |
| | 1902·09 | 133·55 | ... | Espin. |
| $A^1C^1$ | 1830·87 | 244·05 | 48·96 | Σ. |
| | 1867·32 | 244·23 | 48·99 | De. |
| | 1902·11 | 244·7 | 48·8 | Espin. |
| AF (Holmes) | 1902·09 | 129·4 | 13·95 | Espin. |
| $A^2B^2$ (Holmes) | 1902·07 | 216·0 | 5·65 | Espin. |
| $CA^1$ | 1902·11 | 244·7 | 48·8 | Espin. |
| $AA^2$ | 1902·07 | 71·2 | 89·9 | Espin. |

I make the magnitudes as follows: A = 6·0; B = 12·0; C = 6·1; D = 10·8; D = 11·0; F = 11·5; $A^2$ = 9·5; $B^2$ = 10·5. Of Mr. Holmes's other two *comites* one is more distant than D in the same quadrant, and the other is about 10″ from E.

A comparison of the measures of the brighter stars shows that there is no motion within the group so far, and it would be interesting to know if a proper motion can be found for either of these stars.

In the course of the observations two pairs were found and measured:—

No. 1 B.D. +62°·640 R.A. $3^h\ 51^m\ 27^s$ Decl. +62° 10′·3 (1880).

| | | | Mags. | |
|---|---|---|---|---|
| AB | P 221°·3 | D 1″·48 | 8·2 8·5 | 1902·079 |
| | 220·3 | 1·48 | 8·2 8·6 | ·115 |
| AC | 169·7 | 8·2 | 10·5 | ·079 |
| | 169·4 | 8·6 | | ·115 |

[A letter received since the above was written informs me that the pair No. 1 had been previously detected by Bird, and has been measured by Doolittle.]

. +61°·666 R.A. $3^h$ $55^m$ $19^s$, Decl. +61° 50′·5

| | | Mags. | |
|---|---|---|---|
| 247°·5 | D 4″·9 | 8·6 10·0 | 1902·079 |
| 249·9 | 5·1 | 8·5 11·0 | ·112 |

narked " Dupl ? " in the zones of the Astronomische

[*Note added by Mr. Lewis.*]

rincipal stars in this group are *Lalande* 7430 and lowing are the places, brought up to 1890, from ues :

| | R.A. Lalande 7430. | R.A. Lalande 7433. |
|---|---|---|
| | h m s | h m s |
| 1800 | 3 58 8·302 | 3 58 10·392 |
| 1842 | 8·301 | 10·101 |
| 1845 | 8·176 | 10·576 |
| 1865 | 8·122 | 10·322 |
| 1878 | 8·227 | 10·297 |
| 1881 | 8·227 | 10·377 |
| 1895 | 8·102 | 10·228 |

| | N.P.D. Lalande 7430. | N.P.D. Lalande 7433. |
|---|---|---|
| | ° ′ ″ | ° ′ ″ |
| 1800 | 27 57 52·1 | 27 58 4·1 |
| 1842 | 58·07 | 8·0 |
| 1845 | 58·0 | 7·5 |

*Micrometrical and Visual Observations of Nova Cygni* (1876) *made with the 40-inch Refractor of the Yerkes Observatory.* By E. E. Barnard.

On the evening of 1876 November 24, at $5^h\ 45^m$, Schmidt at Athens discovered a brilliant star of the 3rd magnitude in *Cygnus* where a few days previous none such had existed. It rapidly faded, and by December 15 had ceased to be visible to the naked eye. The period of visibility without the telescope, therefore, did not extend over more than twenty-two days.

The most rapid decline in its light occurred between 1876 November 27 and November 29, when, according to Schmidt, in less than two days it faded through nearly 1½ magnitude. From then on until it ceased to be visible to the naked eye the decline was slow and gradual at about 0·13 magnitude a day. By 1877 February 1 it had reached 7·5 magnitude. By 1877 September 1 it had declined to the 10th magnitude, at which brightness it remained for nearly a year. Throughout 1880 and the first part of 1881 it remained constant at slightly less than 12 magnitude. On 1882 March 24 the Dun Echt observers estimated it to be of the 14th magnitude. There seem to be no other observations to verify this last estimation. Nearly ten years later (July 31, 1891) Professor Burnham examined the star with the 36-inch of the Lick Observatory and estimated it to be 13·5 magnitude. He found it a little brighter than the star No. 50, which he estimated to be 14 magnitude. I have not found any later observations of the star.

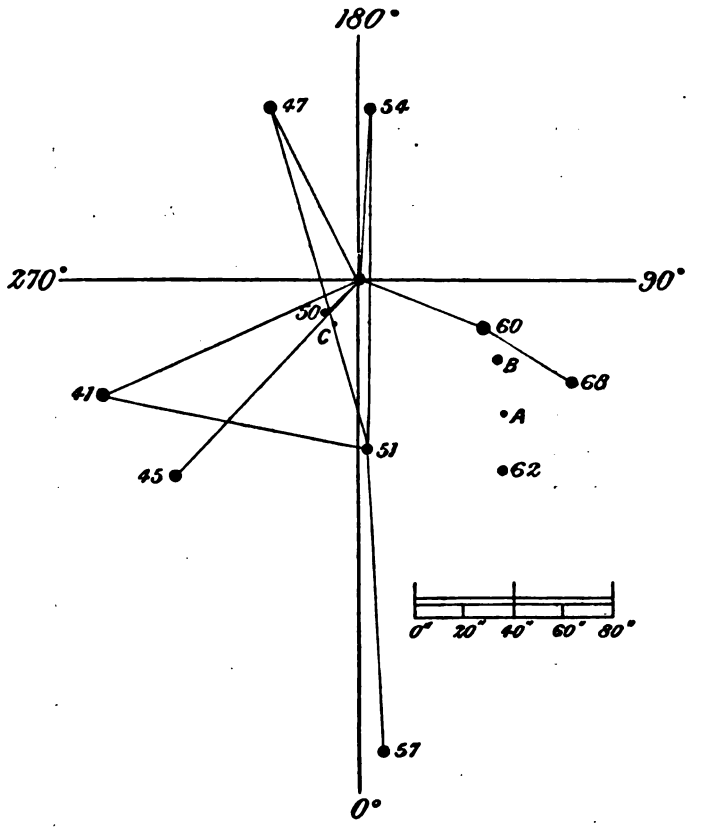
At the observations in 1891 (*Pub. L. O.*, vol. ii., p. 179), Professor Burnham says: "At times the new star did not seem to have a perfectly stellar appearance under moderately high powers, but rather to resemble an exceedingly minute nebula. This appearance, however, may not be real. The star is too faint to allow one to decide a question of this kind with any certainty. I did not make any measures from surrounding stars, as that has been very thoroughly done by the authors of the paper referred to [Copeland and Lohse: *Copernicus*, vol. ii., 101]."

Fearing the possible total disappearance of the *Nova*, Copeland and Lohse made an extensive series of measures of its position with respect to 112 surrounding stars. These observers state in *Copernicus*, vol. ii.: "Towards the end of 1877 October *Nova Cygni* had decreased still further in brightness, and so pointed to the possibility that it might eventually fade altogether from view. In the event of such a contingency it seemed very desirable to possess a map of the small stars in the immediate neighbourhood; accordingly measures in position-angle and distance from the new star to surrounding objects were commenced on October 29 and added to as occasion offered, until the whole series of measures extended to 38 nights, the last being 1882

e resulting map includes every star fairly measur-
)un Echt refractor of 15·06 inches aperture within
*gni.* . . . In this place it may be well to particu-
hall star, probably about the 15th magnitude, at a
'·1, in position-angle 314°·2 from *Nova*, as in a
hination it might possibly be confounded with the
event of the total disappearance of the latter."
ures and a most excellent map of 113 stars (in-
*va*) are printed in *Copernicus*, Nos. 18 and 19,
and July, for a copy of which I am greatly in-
Ralph Copeland, Astronomer Royal for Scotland.
f these stars are reduced to the epoch 1878·0. I
d to Dr. See for copies of the chart and of some
in *Copernicus* from the library of the U.S. Naval

y change has occurred in the place of the new
st quarter of a century, I have selected a few of
re-measurement along with the *Nova*. The re-
f all the stars observed at Dun Echt would be an
ce of labour, I therefore selected those stars near
hich were within about two minutes of arc from it.
looked up this object, on 1901 October 21, I adopted
ion of it given in *Ast. Nach.*, Bd. 89, p. 10, not
rt by which to identify its place. Unfortunately
ion was in error (corrected later on in *A. N.*).
gh the erroneous place coincided to within one
and a few seconds of arc, with a $15^m$ star (No. 51)
ed that night and the next for the *Nova*. Upon
ace of this star from the observed $\Delta\alpha$ and $\Delta\delta$ and

it is an easy matter to identify the corresponding stars in the sky. But you still do not know the number of this or that particular star in the list of measures. If it happens to be at the telescope that a particular star on the chart is wanted to be identified by its number, as is frequently the case, it becomes very annoying and is the source of the loss of much time. I have, therefore, gone to the trouble of identifying the stars on such charts by scale and protractor, and numbering them to save time and confusion.




On the present chart the numbers are those assigned the stars at Dun Echt.

I have inserted four additional stars besides those measured. The star A is very faint = 16½ magnitude. B is of the same brightness as 62, while C, the very faint star mentioned near 50,

difficult under not very fair conditions. The sta
ted because of the comparisons of the light of

g are the measures :—

*ometer Measures of Stars near Nova Cygni* (1876).

Nova and No. 60. Magnitude 11·4.

| | ° | ″ |
|---|---|---|
| Nov. 4 | 70·15 | 52·53 |
| 5 | 70·48 | 53·10 |
| 12 | 70·51 | 52·66* |
| Dec. 4 | 70·58 | 52·47† |
| 17 | 70·25 | 53·06 |
| 30 | 70·05 | 52·96 |
| | 70·34 | 52·80 |

These give $\Delta\alpha = 0^m\ 4^s{\cdot}488$, $\Delta\delta$ 0′ 17″·77.

* Single distances; clouds.
† Two single distances; clouds.

Nova and No. 54. Magnitude 12·1.

| | ° | ″ |
|---|---|---|
| Nov. 4 | 175·27 | 67·83 |
| 5 | 175·94 | 68·08 |
| Dec. 4 | 175·88 | 67·82 |

Nova and No. 50. Magnitude 16·0.

| | | | |
|---|---|---|---|
| 1901·926 | Dec. 4 | 312°·97 | 19″·38* |
| ·961 | 17 | 315·54 | 20·09 |
| ·997 | 30 | 316·05 | 19·87 |
| 1901·961 | | 314·86 | 19·78 |

* There is a 16$^{m}$·8 star close north of 50.

Nova and No. 45. Magnitude 13·7.

| | | | |
|---|---|---|---|
| 1901·961 | Dec. 17 | 316°·28 | 106″·17 |
| ·994 | 29 | 316·28 | 106·05 |
| 1902·005 | Jan. 2 | 316·21 | 105·80 |
| 1901·987 | | 316·26 | 106·01 |

Nova and No. 51. Magnitude 15·3.

| | | | |
|---|---|---|---|
| 1901·844 | Nov. 4 | 2°·48 | 66″·60 |
| ·846 | 5 | 2·34 | 66·68 |
| ·882 | 18 | 2·32 | 66·64 |
| ·926 | Dec. 4 | 2·11 | 66·71 |
| 1901·875 | | 2·31 | 66·66 |

These give $\Delta\alpha = 0^{m}\ 0^{s}\cdot243$, $\Delta\delta = 1'\ 6''\cdot61$.

*Positions of Stars with reference to No.* 51.

No. 51 and No. 57. Magnitude of No. 57, 12·0.

| | | | |
|---|---|---|---|
| 1901·808 | Oct. 22 | 2°·62 | 116″·83 |
| 1902·033 | Jan. 12 | 2·57 | 117·07 |
| ·035 | 13 | 2·55 | 117·21 |
| 1901·959 | | 2·58 | 117·04 |

No. 51 and No. 60.

| | | | |
|---|---|---|---|
| 1901·808 | Oct. 22 | 135°·52 | 67″·98 |
| 1902·033 | Jan. 12 | 135·35 | 68·19 |
| 1901·920 | | 135·43 | 68·08 |

These give $\Delta\alpha = 0^{m}\ 4^{s}\cdot378$, $\Delta\delta = 0'\ 47''\cdot78$.

No. 51 and No. 54.

| | | | |
|---|---|---|---|
| 1901·808 | Oct. 22 | 178°·92 | 133″·86 |
| 1902·033 | Jan. 12 | 178·84 | 134·24 |
| 1901·920 | | 178·88 | 134·05 |

No. 51 and No. 47.

| | | |
|---|---|---|
| Oct. 22 | 195°08 | 140″18 |
| Jan. 12 | 194·64 | 140·17 |
| | 194·86 | 140·18 |

No. 51 and No. 41.

| | | |
|---|---|---|
| Oct. 22 | 258°20 | 105″21 |
| Jan. 12 | 257·90 | 105·21 |
| | 258·05 | 105·21 |

o. 60 and No. 68. Magnitude of No. 68 = 13·5.

| | | |
|---|---|---|
| Jan. 26 | 57°62 | 31″84 |
| 27 | 57·77 | 31·73 |
| | 57·69 | 31·78 |

l the magnifying power used was 460, but some of were made with 700 diameters.
are comparisons of these measures with those made in 1877–82 :—

Nova and No. 41.

cht ... ... 293°4 ... ... 108″6

Nova and No. 51.

| | | | | | | |
|---|---|---|---|---|---|---|
| Dun Echt | ... | ... | 398°·5 | ... | ... | 63″·7 |
| Yerkes ... | ... | ... | 362·3 | ... | ... | 66·7 |
| D. E.–Y. | ... | ... | −3·8 | ... | ... | −3·0 |

Nova and No. 60.

| | | | | | | |
|---|---|---|---|---|---|---|
| Dun Echt | ... | ... | 69°·7 | ... | ... | 55″·2 |
| Yerkes ... | ... | ... | 70·3 | ... | ... | 52·8 |
| D. E.–Y. | ... | ... | −0·6 | ... | ... | +2·4 |

No correction has been applied to the angles for precession.

These discrepancies are rather large. They do not seem to be due to any systematic errors nor to motion in the *Nova*. It is scarcely probable that they are due to motion in any of these small stars themselves.

The Dun Echt observers state, in *Copernicus* Nos. 18–19, p. 117, that "the probable error of one of the places is about ±1″·1 in either coordinate; this quantity is disappointingly large, but is probably to be ascribed in some measure to two special causes—the peculiar light of the *Nova*, which threw its image out of focus, and the fact that the settings could not all be made in the centre of the apparent field of view." The magnifying power used at Dun Echt was nearly always 229.

The star No. 60 is the one mentioned by Schmidt as a companion to the *Nova*, of the 12–13$^m$, 4$^s$·25 fol. and 15″·5 north. Schmidt's position was determined from two transits of a ring micrometer, and are not very exact (*A. N.* 2122, Bd. 89, p. 159).

Following are the observations for the position of the *Nova*, made with respect to the stars Bonn A. G. Cat. 15868 (D.M. +42°·4184) and 15876 (D.M. +42°·4185) :—

*Observed* Δα *and Measured* Δδ.

No. 51 and D.M. +42°·4184.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | m s | | ′ ″ | |
| 1901·805 | Oct. 21 | Δα | 0 24·51 | (10) | Δδ 2 20·41 | (2) |
| ·808 | 22 | | 0 24·50 | (14) | 2 20·92 | (3) |
| 1901·806 | | | 24·50 | (28) | 2 20·71 | (5) |

No. 51 is north preceding.

No. 51 and D.M. +42°·4185.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | m s | | ′ ″ | |
| 1901·805 | Oct. 21 | Δα | 0 34·96 | (10) | Δδ 0 9·10 | (2) |
| ·808 | 22 | | 0 34·90 | (14) | 0 9·67 | (4) |
| 1901·806 | | | 0 34·92 | (28) | 0 9·48 | (6) |

No. 51 is south preceding.

| | | | |
|---|---|---|---|
| | Oct. 29 | $\Delta\alpha$ | $0^m\ 20^s{\cdot}25$ |
| | | No. 60 is north prece | |
| | | No. 51 and No. 60 | |
| 1901·805 | Oct. 21 | $\Delta\alpha$ | $0'\ 47''{\cdot}50$ |
| | | $\frac{1}{4}$ sec $\delta$ (= $4''{\cdot}29$). | |
| | | No. 51 is north preceding | |
| | | Nova and No. 60. | |
| 1901·827 | | $\Delta\alpha$ | $0'\ 51''{\cdot}00$ (4) |
| | | $\frac{1}{4}$ sec $\delta$ (= $4''{\cdot}60$) reject | |
| | | Nova is south preceding No | |

At the observations for $\Delta\alpha$ *Nova* was measures should be rejected.

All the measures have been corrected f

As the comparisons with the Dun Echt to indicate with any certainty any motio occurred to me that this question might b parisons of some of the stars and the *Nov* stars following the new star, which have meridian, and with the meridian observatio made some twenty-five years ago.

This investigation follows.

The star D.M. $+42°{\cdot}4184$ has been obs Echt, and Greenwich. These positions brou in fair accord—

D.M.

The star D.M. +42°·4185 has been observed at Bonn.

1901·0 $21^h\ 38^m\ 24^s{\cdot}60$ $+42°\ 24'\ 39''{\cdot}5$ Bonn A.G. Cat

From the first of these stars (42°·4184) we get the following position for star 51 from the observed $\Delta\alpha$ and $\Delta\delta$.

Star 51 1901·0 $\alpha = 21^h\ 37^m\ 49^s{\cdot}88$ $\delta = +42°\ 24'\ 31''{\cdot}36$ (A)

And this, with the observed position-angle and distance, gives the following position :

Nova 1901·0 $\alpha = 21^h\ 37^m\ 49^s{\cdot}67$ $\delta = +42°\ 23'\ 24''{\cdot}70$ . (1)

From the same star (42°·4184) the following position of No. 60 is obtained from the observed differences of $\alpha$ and $\delta$ :

Star 60 1901·0 $\alpha = 21^h\ 37^m\ 54^s{\cdot}13$ $\delta = +42°\ 23'\ 42''{\cdot}69$ (*a*)

From the position-angle and distance this gives for the

Nova 1901·0 $\alpha = 21^h\ 37^m\ 49^s{\cdot}64$ $\delta = +42°\ 23'\ 24''{\cdot}92$ (2)

From the second star (42°·4185) we similarly deduce the following position of

No. 51 1901·0 $\alpha = 21^h\ 37^m\ 49^s{\cdot}67$ $\delta = +42°\ 24'\ 30''{\cdot}12$ (B)

From which the position of the *Nova* is derived as before.

Nova 1901·0 $\alpha = 21^h\ 37^m\ 49^s{\cdot}43$ $\delta = +42°\ 23'\ 23''{\cdot}51$ (3)

This star (42°·4185) also gives the place of

No. 60 1901·0 $\alpha = 21^h\ 37^m\ 53^s{\cdot}95$ $\delta = +42°\ 23'\ 41''{\cdot}52$ (*b*)

And this in turn gives for the *Nova* :

Nova 1901·0 $\alpha = 21^h\ 37^m\ 49^s{\cdot}46$ $\delta = +42°\ 23'\ 23''{\cdot}75$ (4)

Collecting these four positions of the *Nova* for 1901·0 we have

| | h m s | ° ′ ″ |
|---|---|---|
| (1) | $\alpha = 21\ 37\ 49{\cdot}67$ | $\delta = +42\ 23\ 24{\cdot}70$ |
| (2) | 21 37 49·64 | 42 23 24·92 |
| (3) | 21 37 49·43 | 42 23 23·51 |
| (4) | 21 37 49·46 | 42 23 23·75 |
| 1901·0 | $\alpha = 21\ 37\ 49{\cdot}55$ | $\delta = +42\ 23\ 24{\cdot}22$ |

The two first positions, depending on star 42°·4184, and the two last, on star 42°·4185, show a systematic difference amounting to $0^s{\cdot}2$ and $1''$ in $\alpha$ and $\delta$ respectively. This is perhaps due to motion in one or the other of the two stars.

| | | | |
|---|---|---|---|
| | | 21 37 49·55 | |
| | | 21 37 49·40 | |
| 1901·0 | $\alpha$ = | 21 37 49·49 | $\delta$ = + |

The weights assigned there are f
tions. One of the observations at V
as it was observed under poor condit

Comparison of the mean of these
shows no certain change in the place

The agreement would be closer if
referred to 42°·4185 alone. As this l
observations it would seem that there
the place of 42°·4184 and no change in

The magnitudes I have assigned to
each case of several estimates.

Following are comparisons of the m

Star 41.

| | | m | |
|---|---|---|---|
| Dun Echt ... ... ... | | 13·4 | Dun |
| Yerkes ... ... ... | | 13·2 | Yerl |
| D. E. – Y. ... ... ... | | +0·2 | D. E |

Star 42.

| | | | |
|---|---|---|---|
| Dun Echt ... ... ... | | 15·0 | Dun |
| Yerkes ... ... ... | | 14·0 | Yerl |
| D. E. – Y. ... ... ... | | +1·0 | D. E |

Star 45.

Dun Echt ...

| Star 57. | | Star 68. | |
|---|---|---|---|
| Dun Echt ... ... ... | 13·4 | Dun Echt ... ... ... | 14·0 |
| Yerkes ... ... ... | 12·0 | Yerkes ... ... ... | 13·2 |
| D. E.−Y. ... ... ... | +1·4 | D. E.−Y. ... ... ... | +0·8 |

| Star 60. | | Star 73. | |
|---|---|---|---|
| Dun Echt ... ... ... | 11·0 | Dun Echt ... ... ... | 13·4 |
| Yerkes ... ... ... | 11·4 | Yerkes ... ... ... | 12·5 |
| D. E.−Y. ... ... ... | −0·4 | D. E.−Y. ... ... ... | +0·9 |

Collecting these differences of magnitude, we have :—

| m | m |
|---|---|
| +0·2 | −0·1 |
| +1·0 | +1·4 |
| +0·7 | −0·4 |
| −0·3 | +0·8 |
| +0·7 | +0·9 |
| −1·0 | D. E.- Y.= +0·2 |
| −1·0 | |

The magnitudes of those stars which were not micrometrically measured by me should not have much weight, as they would not be so carefully estimated.

These discordances of magnitude are not very large, and no more than would be expected from different observers with different telescopes and such faint objects as some of these stars are.

It must be understood, however, that these estimates have been made under the most unfavourable conditions of seeing here, when a star anyways near the limit of the 40-inch would not be seen.

On several occasions I have seen a very faint star near No. 50 and north of it. It was too faint to measure—and there was no reason for measuring it.

By estimation, in terms of other distances and position-angles, this small star would be, with reference to No. 50, in

P. 20°± Dist. 5″±.

No. 50 is a faint star to have been measured at Dun Echt. There does not seem to have been any change in its brightness, though one would almost infer that it must have been brighter some twenty or twenty-five years ago.

It is difficult to estimate the brightness of the *Nova*. It seems to be more affected by bad seeing or moonlight than the small stars near it. This is another indication of its probable nebulous

My estimates of its relative light seemed to show
d through about $\frac{1}{3}$ magnitude. This, I think, how-
o its lack of exact definition and the effect of local
moonlight or bad seeing, though I am not sure
e is not a fluctuation of its light.
are estimations of the brightness of the *Nova* with
e stars 50 and 51.

*mparisons of the Brightness of the Nova.*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12 | *Nova* | = 51 | and possibly slightly brighter. | | | | |
| 18 | ,, | = 51. | | | | | |
| 19 | ,, | = $\frac{5}{10}^{m}$ | less than 51. | | | | |
| 4 | ,, | = $\frac{2}{10}^{m}$ | ,, | ,, | $\frac{2}{10}^{m}$ | brighter | than 50. |
| 17 | ,, | = $\frac{3}{10}^{m}$ | ,, | ,, | $\frac{5}{10}^{m}$ | ,, | ,, |
| 22 | ,, | = $\frac{5}{10}^{m}$ | ,, | ,, | $\frac{1}{10}^{m}$ | ,, | ,, |
| 29 | ,, | = 51 | ... | ... | $\frac{5}{10}^{m}$ | ,, | ,, |

wing estimates are more carefully made and are
e more exact. They were made specially to decide
of variability.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | *Nova* | $\frac{1}{10}^{m}$ | less than 51 | ... | $\frac{4}{10}^{m}$ | brighter | than 50. |
| 2 | | midway between 50 and 51. | | | | | |
| 5 | | $\frac{3}{10}^{m}$ | less than 51 | ... | $\frac{1}{10}^{m}$ | ,, | ,, |

the following two determinations of the present brightness of *Nova Cygni* result from star 50, $15^{m}\cdot7$, and from star 51, $15^{m}\cdot6$.

From ten nights' comparisons the star No. 62 was found to be equal to No. 50 (the mean gave $0^{m}\cdot03$ less than No. 50), while from eleven nights' estimates, No. 62 was found to be $0^{m}\cdot35$ less than the *Nova*.

Twelve nights' comparisons made No. 51 less than No. 68 by $0^{m}\cdot18$.

In all the estimates of brightness the eyes were placed parallel to the line joining the stars. This is very important in my case, for, as I have shown in *A. J.* 370, vol. xvi. p. 75, two stars that are equal when the line between them is parallel to my eyes, will differ by half a magnitude when they are in a vertical line; the lower one being always the brighter. Just what is the cause of this peculiarity is not clear, but it seems that it might be due to a dulling of a portion of the retina by the preponderance of the illumination of the sky in the daytime over that of the landscape, about one half of the retina usually receiving the light from the sky, while the other half receives that from the landscape. The lower star would therefore fall on that part of the retina usually occupied by the landscape, and hence on a more sensitive portion.

Mr. J. A. Parkhurst has kindly measured the relative light of Nos. 50 and 51 with the photometer on the 40-inch. The difference as determined by him is $0^{m}\cdot66$ from one night's observations under rather unfavourable conditions. This is a little larger than the difference that would be derived from my estimates with the *Nova* and these two stars, and agrees almost exactly with the difference of my estimates of the magnitudes ($0^{m}\cdot7$) of the two stars themselves.

The changes of colour in this star were not very remarkable. At the time of discovery by Schmidt it was of a strong golden yellow. This colour, according to Schmidt, it retained until it ceased to be visible to the naked eye—to him it was at no time of a decided orange tint, but yet of a full yellow. When observable only with the telescope some of the observers described it as red.

According to Dr. Copeland, at Dun Echt, the star presented a rather complicated spectrum during its brighter stages in 1876 and the beginning of 1877. On 1876 December 5, when its magnitude was 4·5, he found that one of the spectral lines coincided almost exactly with the brightest line of the gaseous nebulæ. Another line corresponded very nearly with one of the bright lines in the spectra of the Wolf-Rayet stars in *Cygnus*. In the next eight or nine months the spectrum was reduced to a single line with the merest traces of a continuous spectrum. The star itself was later described as having "a small disc with a soft margin;" the *Nova* seemingly having become a nebula, both visually and spectroscopically. In reference to this remarkable change in the physical condition of the star, Dr. Copeland says, in *A. N.* 2158:—"Bearing in mind the history of this star from

the time of its discovery by Schmidt, it would seem certain that we have an instance before us in which a star has changed into a planetary nebula of small angular diameter. At least it may be safely affirmed that no astronomer discovering the object in its present state would, after viewing it through a prism, hesitate to pronounce as to its present nebulous character."

One striking feature about *Nova Cygni* mentioned by the Dun Echt observers was the fact that there was a decided difference in the focal adjustment for it and a star. According to Dr. Copeland, with the 15-inch Grubb refractor, this amounted on 1877 October 2, when the star was about $10^m$, to about 2 mm. (the focus being outside of that for a star). In this respect it resembled *Nova Aurigæ* rather than *Nova Persei* of the past year. There seems to be no record of anything of this kind in its earlier stages of brightness in 1876, and it probably showed no such peculiarity then.

So far as I can learn, *Nova Aurigæ* in its first appearance, when bright, did not show this peculiarity, nor even when faint in the spring of 1892. It was only at its second apparition that the effect became evident. At present *Nova Persei* has shown nothing of this kind. In all probability, however, it will show it later on when it has become much less bright. It is the intention to frequently test the focus to see when this effect first becomes visible—if it makes its appearance at all. Careful tests up to 1902 January 31 showed no sensible difference between its focus and that of a star.

On account of the faintness of *Nova Cygni* it is difficult now to measure its focus with reference to a star in the ordinary way. Under the best seeing, however, there is certainly a slight difference of focus to the extent of possibly $\frac{1}{10}$-inch outside of that for a star. Even when in best focus it does not appear to be perfectly sharp. It seems to be more or less ill-defined, resembling in this the present appearance of *Nova Aurigæ*. Of course no colour is ever discernible in so faint an object.

I have examined *Nova Coronæ* (1866) several times lately, but always under very bad conditions of seeing. Under those conditions no difference of focus was noticeable between it and a star—though I hope to investigate this point more carefully later on with better seeing.

I have mentioned the want of *Nova Persei* to show any peculiarity in its focus from that of a fixed star. There is another peculiarity which I believe is important, but which in the greater interest due to the photographic nebulosity about the *Nova* is lost sight of. In the *Astrophysical Journal* for 1901 October, vol. xiv. No. 3, attention is called to the peculiar appearance of the *Nova* in the 40-inch: "On August 12, the seeing was unusually good; examining the *Nova* with high powers I was struck with its appearance. It was brighter than the star [D.M. $+43°\cdot732$], but under high magnifying powers its light was strikingly dull, having more the appearance of planetary

light. This was so decided, that had I been examining the stars in that region I should at once have singled out the *Nova* as different from any of the stars. The spurious disc appeared much duller and somewhat larger than that of a star, and of a slight yellowish colour."

As the new star has faded, this peculiarity has become even more striking. The light of the *Nova*, which is greenish white, is very much like that of *Neptune*, and when *Neptune* is seen with a power that just begins to show its disc, the general likeness to the *Nova* would be striking. The light, however, is more greenish than that of *Neptune*. It also strongly resembles *Ceres* when that planet is seen with not too high a power. The colour is also like some of the planetary nebulæ—especially N.G.C. 7662 in *Andromeda*. While the light from a star is vivid, that of *Nova Persei* is singularly dull with high powers.

*Yerkes Observatory, Williams Bay, Wisconsin:*
1902 *February* 5.

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*On the Variation of S Carinæ.* By Alex. W. Roberts, D.Sc.

There are at present (February 1902) between 160 and 180 stars south of $-30°$ dec., whose variation is known with some degree of certainty.

Of this number ten are of marked interest, as their variation was discovered and definite minima and maxima determined by Dr. Gould. The star *S Carinæ* (Ch. 3637) is one of these Cordoba variables. Inasmuch as I have already dealt with the variation of *R Carinæ* (*Monthly Notices*, vol. lxi. p. 552) and with the variation of *R Centauri* (*Monthly Notices*, vol. lxi. p. 355), both stars whose variation was discovered and defined by Dr. Gould, it will, I think, give a measure of completeness to these papers to consider also the variation of *S Carinæ*.

It may be noted here that the three stars are good examples of three well-defined types of long-period variation.

We consider in the first place the data which are of service as leading to a determination of the period of the star.

Dr. Gould's note on the variation of *S Carinæ* is as follows (*Uranometria Argentina*, p. 253):—

"The fluctuations of the light of this star appear to be within the limits $6\frac{1}{4}^m$ and a little above $9^m$, and the length of its period to be several months. In 1872 its magnitude was observed as follows: T., May 26,* 7·0; April 3, 6·9; H., May 24, 30, 8·0; R., July 28, 7·9; Aug. 7, 7·4. In 1874 it was twice observed by Mr. Thome, May 21, 6·3; June 9, 7·3; observations which place the variability of the star beyond question.

* March 26?

"In May 1877 he estimated it as $8\frac{1}{4}^m$. Amid the great amount of other labour, sufficient observations have not been made to enable me to determine the light curve; but with the certainty of its variability I have not hesitated to designate it *S Carinæ*. Its colour is decidedly reddish."

Although Gould's observations are not sufficient to yield a period they are so situated on the light curve that they afford an indication of a definite date when the star passed through its maximum phase in 1872.

Later on in the present investigation this date will be determined and a period deduced from it. It is necessary first, however, to consider the more recent observations. These alone are sufficient to yield complete elements of variation, and thus they readily admit of being related to the Cordoba observations.

Observations of *S Carinæ* were begun at Lovedale in April 1891, and have been continued with one short interval down to the present. The number of observations secured during this period is close on 800. Nearly all the observations were made with a good 1-inch telescope, the usual precautions being taken to eliminate position error.

In the following two tables are given the several maxima and minima determined from the Lovedale observations. For purposes of computation the Julian day is given in the third column. In the fourth column is set forth the magnitude at maximum or minimum phase. In the last column is given the difference between these observed magnitudes and the mean magnitude for the whole series, viz. $6^m{\cdot}2$ for maximum and $8^m{\cdot}9$ for minimum.

TABLE I.

*Determination of Maxima.*

| Rotation No. | Date. | Julian Day. J | Mag. m | Diff. m |
|---|---|---|---|---|
| 1 | 1891 June 30 | 2411914 | 6·2 | 0·0 |
| 2 | 1892 April 17 | 2412206 | 5·8 | −0·4 |
| 3 | 1893 Feb. 7 | 2412502 | 5·9 | −0·3 |
| 4 | June 30 | 2412645 | 5·9 | −0·3 |
| 5 | Nov. 30 | 2412798 | 6·0 | −0·2 |
| 6 | 1894 May 9 | 2412958 | 6·6 | +0·4 |
| 7 | Sept. 27 | 2413099 | 6·0 | −0·2 |
| 8 | 1895 July 21 | 2413396 | 5·7 | −0·5 |
| 9 | Dec. 28 | 2413556 | 6·7 | +0·5 |
| 10 | 1896 May 21 | 2413701 | 6·0 | −0·2 |
| 11 | Oct. 16 | 2413849 | 5·8 | −0·4 |
| 12 | 1898 Oct. 24 | 2414587 | 6·3 | +0·1 |
| 13 | 1899 Mar. 28 | 2414742 | 6·6 | +0·4 |
| 14 | Aug. 20 | 2414887 | 6·3 | +0·1 |

| Rotation No. | Date. | Julian Day. J | Mag. m | Diff. m |
|---|---|---|---|---|
| 15 | 1900 Jan. 24 | 2415044 | 6·6 | +0·4 |
| 16 | June 11 | 2415182 | 6·0 | −0·2 |
| 17 | Nov. 10 | 2415334 | 6·2 | 0·0 |
| 18 | 1901 April 7 | 2415482 | 6·4 | +0·2 |
| 19 | Aug. 29 | 2415626 | 5·8 | −0·4 |
| 20 | 1902 Jan. 22 | 2415772 | 6·6 | +0·4 |

TABLE II.

*Determination of Minima.*

| Rotation No. | Date. | Julian Day. J | Mag. m | Diff. m |
|---|---|---|---|---|
| 1 | 1892 Feb. 8 | 2412137 | 9·4 | +0·5 |
| 2 | July 6 | 2412286 | 9·2 | +0·3 |
| 3 | Nov. 19 | 2412422 | 8·8 | −0·1 |
| 4 | 1893 May 3 | 2412587 | 9·0 | +0·1 |
| 5 | Sept. 20 | 2412727 | 8·7 | −0·2 |
| 6 | 1894 Feb. 15 | 2412875 | 9·2 | +0·3 |
| 7 | July 15 | 2413025 | 9·3 | +0·4 |
| 8 | 1895 May 13 | 2413327 | 8·7 | −0·2 |
| 9 | 1896 Mar. 13 | 2413632 | 8·7 | −0·2 |
| 10 | Aug. 2 | 2413774 | 8·9 | 0·0 |
| 11 | 1898 Aug. 18 | 2414520 | 9·0 | +0·1 |
| 12 | 1899 Jan. 9 | 2414664 | 8·9 | 0·0 |
| 13 | June 8 | 2414814 | 8·9 | 0·0 |
| 14 | Oct. 29 | 2414957 | 8·9 | 0·0 |
| 15 | 1900 Mar. 27 | 2415106 | 8·7 | −0·2 |
| 16 | Aug. 25 | 2415257 | 8·7 | −0·2 |
| 17 | 1901 Jan. 24 | 2415409 | 8·7 | −0·2 |
| 18 | June 15 | 2415551 | 9·1 | +0·2 |
| 19 | Nov. 19 | 2415708 | 9·3 | +0·4 |

It is not necessary to give prominence to the minor details of this investigation, which has for its purpose the determination of the elements of *S Carinæ* from the foregoing data. Indeed it would be tedious to do so. I may therefore confine myself to a statement of the main points and results of the investigation.

(1) If the dates of maximum or minimum phase be grouped in sets of three years, and if a mean period be obtained from each of these sets, there will appear evidence that the period of the star is subject to secular variation

It would seem that the cycle is completed in about nineteen years, or forty-five light periods, although on this matter the evidence is far from conclusive, as it must of necessity be, from

$J_M$ = Julian day of observed m

$J_m$ = Julian day of observed mi

We may regard the secular variatio character represented by the expressio

$$\kappa \cos (\phi E - M)$$

As a first approximation we take,

$$\phi = 8°;$$

that is, the cycle of perturbations is com periods.

It is evident that, with regard to (Table I.), the relation between the fo forth by the equation :—

$$(T_M + \Delta t_M) + E(P + \Delta p) + \kappa \cos (8° ]$$

Let now $x = \kappa \cos M$

$= \kappa \sin M,$

and equation (1) becomes for maxima det

$$\Delta t_M + E\Delta p + x \cos 8° E + y \sin 8° E =$$

and for minima determinations

$$\Delta t_m + E\Delta p + x \cos 8° E + y \sin 8° E$$

*Maxima determinations.*—A rigorous consideration of the twenty equations yielded the following values :—

$$\Delta p = -0^{d}\cdot29$$
$$\Delta t_{M} = -5\cdot57$$
$$x = +3\cdot74$$
$$y = -3\cdot56$$

that is,

$$P + \Delta p = 148^{d}\cdot71$$
$$T_{M} + \Delta t_{M} = 2415032\cdot4^{J}$$

Secular variation

$$= 5\cdot2^{d} \cos (8° E - 316°\cdot3).$$

*Minima determinations.*—A similar but quite distinct solution of the nineteen equations (Table II.) yielded the following values :—

$$\Delta p = -0\cdot28^{d}$$
$$\Delta t_{m} = -4\cdot10$$
$$x = +1\cdot91$$
$$y = -3\cdot56$$

that is

$$P + \Delta p = 148\cdot72^{d}$$
$$T_{m} + \Delta t_{m} = 2415107\cdot9^{J}$$

Secular variation

$$= 4\cdot1^{d} \cos (8° E - 331°\cdot7).$$

The close agreement between the results obtained from a separate consideration of the data in Table I. and the data in Table II. is strong presumptive evidence of the accuracy, not only of the value of the period obtained, but more especially of the amount and character of the secular variation.

Combining the two sets of results we have as the final and definitive values of the elements of *S Carinæ* :—

$$J_{M} = 2415032\cdot4^{J} + E\, 148\cdot72^{d} + 4\cdot7^{d} \cos (8° E - 324°)$$
$$M - m = 73\cdot2^{d}.$$

(4) In Tables III. and IV. is exhibited the amount of accordance between theory and observation.

The third column in both tables contains the observed dates

ven in Tables I. and II.; and the fourth column
uted from the elements just determined. The resid
ed in the last column.

TABLE III.

*Maxima Observations.*

| F. | Observed Date. J | Computed Date. J | O- |
|---|---|---|---|
| −21 | 2411914·0 | 2411906·2 | + |
| 19 | 2412206·0 | 24122046 | + |
| 17 | 2412502·0 | 2412503·4 | − |
| 16 | 2412645·0 | 2412652·8 | − |
| 15 | 2412798·0 | 2412802·1 | − |
| 14 | 2412958·0 | 2412951·4 | + |
| 13 | 2413099·0 | 2413100·7 | − |
| 11 | 2413396·0 | 2413399·4 | − |
| 10 | 2413556·0 | 2413548·6 | + |
| 9 | 2413701·0 | 2413697·7 | + |
| 8 | 2413849·0 | 2413846·7 | + |
| 3 | 2414587·0 | 2414590·8 | − |
| 2 | 2414742·0 | 2414739·4 | + |
| − 1 | 2414887·0 | 2414887·8 | − |

| Rotation No. | E. | Observed Date. J | Computed Date. J | O—C. d |
|---|---|---|---|---|
| 6 | −15 | 2412875·0 | 2412877·6 | −2·6 |
| 7 | 14 | 2413025·0 | 2413026·9 | −1·9 |
| 8 | 12 | 2413327·0 | 2413325·6 | +1·4 |
| 9 | 10 | 2413632·0 | 2413624·1 | +7·9 |
| 10 | 9 | 2413774·0 | 2413773·2 | +0·8 |
| 11 | 4 | 2414520·0 | 2414517·7 | +2·3 |
| 12 | 3 | 2414664·0 | 2414666·3 | −2·3 |
| 13 | 2 | 2414814·0 | 2414814·9 | −0·9 |
| 14 | − 1 | 2414957·0 | 2414963·3 | −6·3 |
| 15 | 0 | 2415106·0 | 2415111·7 | −5·7 |
| 16 | + 1 | 2415257·0 | 2415260·0 | −3·0 |
| 17 | 2 | 2415409·0 | 2415408·2 | +0·8 |
| 18 | 3 | 2415551·0 | 2415556·4 | −5·4 |
| 19 | + 4 | 2415708·0 | 2415704·5 | +3·5 |

Mean residual $3^d·7$.

(5) In Tables I. and II. is given the libration on either side of the mean magnitude at maximum and minimum phase.

There was some expectation that this libration would, after the manner of the inequalities in period, follow some regular law.

It is evident, however, that the residuals given in the last column of Tables I. and II. are not systematic in their character; or, at any rate, there is so little evidence of systematic discordance that we may safely assume that it does not exist.

(6) It is pertinent to this investigation to relate the Cordoba observations of *S Carinæ* to those made at Lovedale.

Dr. Gould's observations are as follows :—

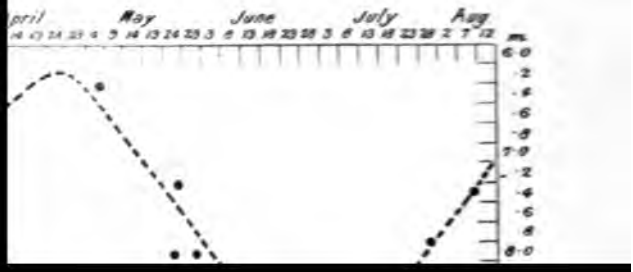
| Observed Date. | Reduced Date. | Mag. |
|---|---|---|
| 1872 Mar. 26 | 1872 Mar. 26 | 7·0 |
| April 3 | April 3 | 6 9 |
| May 24 | May 24 | 8·0 |
| ,, 30 | ,, 30 | 8·0 |
| July 28 | July 28 | 7·9 |
| Aug. 7 | Aug. 7 | 7·4 |
| 1874 May 21 | May 6 | 6·3 |
| June 9 | ,, 25 | 7·3 |

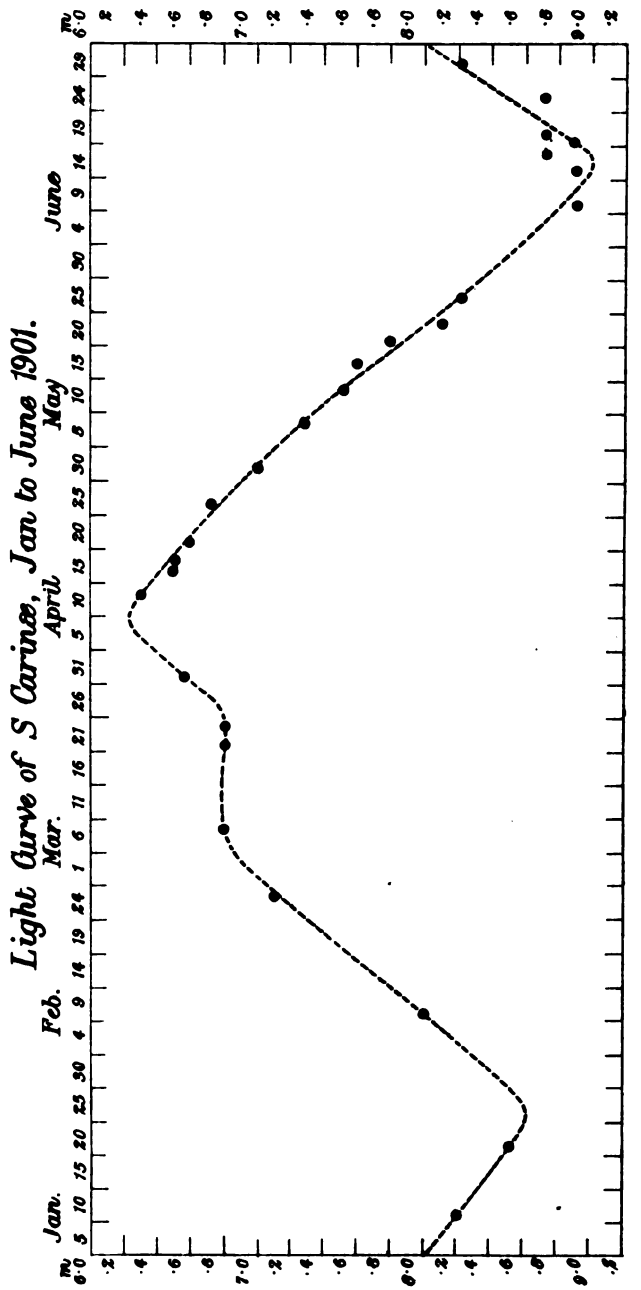
In the second column of the above table are given the dates of the first column reduced to one mean light period, that of March to August 1872.

rder of time sequence, these observations are :—

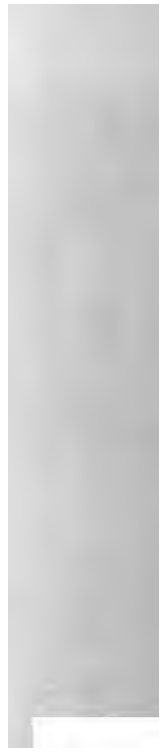
| 1872. | Mag. |
|---|---|
| Mar. 26 | 7·0 |
| April 3 | 6·9 |
| May 6 | 6·3 |
| ,, 24 | 8·0 |
| ,, 25 | 7·3 |
| ,, 30 | 8·0 |
| July 28 | 7·9 |
| Aug. 7 | 7·4 |

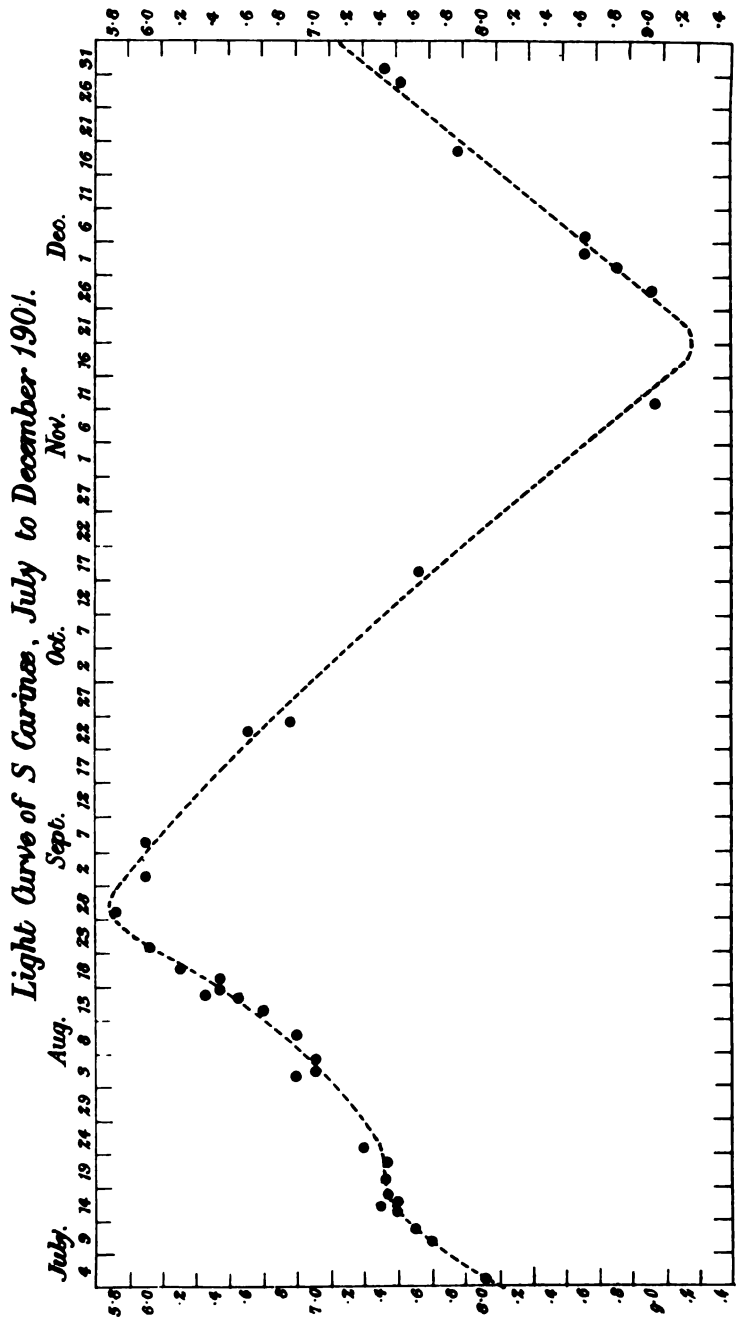
t from the following chart that these eight obser-
e a maximum of $6^m{\cdot}2$ on or about 1872 April 24,
n of $9^m{\cdot}0$ on 1872 July 1.




Light Curve of S Carinæ, Jan to June 1901.
Jan.
Feb.
Mar.
April
May
June
m
6·0
7·0
8·0
9·0






Light Curve of S Carinæ, July to December 1901.
July.
Aug.
Sept.
Oct.
Nov.
Dec.



Lovedale mean light curves as 10127 days, we find that sixty-eight periods are performed in this time, giving a mean period of

$$148^{d}\cdot9.$$

This value is in satisfactory agreement with that found from Lovedale observations alone, viz.

$$148^{d}\cdot72.$$

If we take a mean between these two values we shall arrive at a value of the period correct to within one-tenth of a day.

(7) In plates 9 and 10 are represented graphically the light changes of *S Carinæ* during the year 1901.

The main characteristics of the light curve are (1) the practically equal duration of the increasing and decreasing phases, and (2) the indistinct secondary maximum which takes place about forty days before primary maximum.

With regard to the equality that exists between decreasing and increasing phases, the numerical values are:—

| | d. |
|---|---|
| Increasing phase ... ... ... ... | 73·2 |
| Decreasing phase ... ... ... ... | 75·5 |
| Difference ... ... ... | 2·3 |

It has been shown that a similar tendency to equality between increasing and decreasing phase exists in the case of the long period *T Centauri* (*Monthly Notices*, vol. lxii. p. 69).

In this case the values are :—

| | d. |
|---|---|
| Increasing phase ... ... ... ... | 44·1 |
| Decreasing phase ... ... ... ... | 46·5 |
| Difference ... ... ... | 2·4 |

In neither of these instances, therefore, is a rapid ascent to maximum a feature of the star's variation. Similar instances could be multiplied, but these two definite determinations are sufficient to form an exception of some weight to the view which sometimes prevails that in all cases of long period variation the rise to maximum is very much more rapid than the fall to minimum.

The secondary maximum, which is of a very rudimentary character, is sometimes entirely absent. In one of the 1901 light curves there is only slight evidence of its existence. The phenomenon is therefore irregular in its nature.

Apart from this exception, however, all the other features of variation of *S Carinæ* are of marked regularity. Its return to maximum or minimum can be predicted within a few days; its limits of variation are subject to no erratic fluctuations, and there

neral conformity to a common type of variation in
ırves.
ion type is indicated in the plates which accompany

02 *February* 1.

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*Stars found during the Measurements for the : Catalogue at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

ırse of the measurement of the plates for the
ıap of the heavens, under Mr. Hollis's direction, a
made of large differences of diameter of images
ır on the overlapping plates which are measured
in the duplex micrometer.
ing four stars were in this way found to be
heir diameter on other plates were measured ; the
the third one was announced by Dr. Anderson in
ıer three appear to be new :—

| Approx. R.A. 1900. | Approx. Dec. 1900. |
|---|---|

A shows on these photographs changes of magnitude from nearly $9^{m}\cdot0$ to below the limit reached by chart plates of $40^{m}$ exposure or a nominal $14^{m}\cdot0$.

B shows almost as great a range, as it varies from $9^{m}\cdot5$ of the B. D. to nearly the limit of the chart plates.

The following table shows the variation of C (*U Draconis*) as shown by the measures of diameter :—

| No of Plate. | Date. | Exp. m | C | 67°1118 8·9 | 67°1120 9·2 | 67°1113 9·5 |
|---|---|---|---|---|---|---|
| 483 | 1892 Aug. 5 | 40 | 60 | 70 | 58 | 56 |
| 1380 | 1893 „ 19 | 6 | 18 | 46 | 38 | 39 |
| 1381 | 1893 „ 19 | 40 | 40 | 82 | 68 | 58 |
| 2136 | 1894 July 11 | 6 | 0 | 44 | 39 | 35 |
| 2288 | 1894 Oct. 16 | 6 | 4 | 33 | 32 | 19 |
| 3200 | 1896 July 12 | 40 | 3 | 80 | 64 | 52 |
| 5666 | 1901 „ 8 | 6 | 10 | 54 | 44 | 36 |

These measures show that C was only a little below $9^{m}\cdot0$ on 1892 August 5, and 1896 July 12 was only just shown on a chart plate of $40^{m}$ exposure.

The following table shows in a similar manner the variations in magnitude of D :—

| No. of Plate. | Date. | Exp. m | D | 74°275 8·1 | 74°267 8·2 | 74°272 9·3 | 74°266 9·5 |
|---|---|---|---|---|---|---|---|
| 3796 | 1897 Dec. 24 | 40 | 38 | 123 | 94 | 92 | 58 |
| 3869 | 1898 Feb. 23 | 40 | 20 | 103 | 84 | 78 | 62 |
| 3886 | 1898 Mar. 2 | 6 | 0 | 58 | 42 | 42 | 24 |
| 4302 | 1899 Feb. 25 | 6 | 40 | 54 | 42 | 34 | 22 |
| 5410 | 1901 Feb. 11 | 40 | 0 | 80 | 66 | 60 | 44 |

The above measures show that this star was between the 8th and 9th magnitudes on 1899 February 25, and on 1901 February 11 was below the limit of the chart plates.

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*The Magnitude of η Argûs* 1900–1902. By R. T. A. Innes.

The two comparison stars used are given in the *Monthly Notices*, vol. lix. p. 570.

| | Mag. | Colour. | Means. Date. | Mag. | Colour. |
|---|---|---|---|---|---|
| 1900 Feb. 26 ... ... | 7·7 | 6 | | | |
| Mar. 31 ... ... | 7·65 | 6 | 1900·3 | 7·68 | 6·3 |
| June 8 ... ... | 7·7 | 7 | | | |

| | Mag. | Colour. | Means. Date. | Mag. | Colour. |
|---|---|---|---|---|---|
| 1 | 7·9 | 7 | | | |
| 22 ... ... | 7·7 | 6·5 | 1901·3 | 7·78 | 6·8 |
| 8 ... ... | 7·75 | 7 | | | |
| 26 ... ... | 7·7 | 6·5 | | | |
| 1 ... ... | 7·65 | 6·5 | 1902·1 | 7·72 | 6·5 |
| 8 ... ... | 7·8 | 6·5 | | | |

7-in. Merz equatorial, as before.

*...tory Cape of Good Hope:*
*February* 10.

*...fessor Turner's Recent Paper on Photographic Surveying.* By H. G. Fourcade.

(*Communicated by Sir David Gill.*)

*...nthly Notices* for December 1901 there appears a ...fessor Turner, F.R.S., on "A Simple Method of ...veying with an Ordinary Camera."

...method noticed by Professor Turner, in which a ... is taken at right angles to a base line, has, in its ...een used by me for some years, and, improved in ...eed, convenience, and accuracy by the proposed

it as seen by me than that given by W. H. Pickering (*Monthly Notices*, vol. lxii. p. 85).

When the Sun is seen through a telescope low down it is bordered at its lower edge, owing to refraction, with the red end of the spectrum, which looks on the whole red or orange-red, while at its upper edge it is bordered with the violet end, which is on the whole green, the extreme end of the spectrum being of course absorbed by the atmosphere. The edges necessarily boil much, but the last portion to set must naturally be a part of the green upper edge, and although I have not observed the green flash with the telescope it is obvious that it is this green edge that is last seen by the naked eye; the boiling of the edge will no doubt account for the appearance like Baily's beads described by one observer with instrumental means.

*West Hendon House, Sunderland:*
1902 *Jan.* 16.

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## *Note on the "Green Flash" at Sunset.*

By Major E. H. Hills, R.E.

The notes on this subject by Mr. W. H. Pickering (*Monthly Notices*, lxii. p. 85, 1901 November) and Mr. Backhouse above have suggested to me that it may be of some interest if I give a short account of my observations of this phenomenon and of the conclusions I have reached as to its cause. There is, I believe, no doubt that it is of spectral origin, the green being the visually predominant colour in a solar spectrum which attains the requisite degree of purity when the light source, namely the diminishing segment of the Sun's disc, becomes narrow.

If this explanation be the correct one, it will follow that, though the green may be by far the strongest colour, it will not be the last one visible, and a careful scrutiny, under suitable telescopic power, should reveal the more refrangible parts of the expiring spectrum, and thus, as the last portion of the Sun's rim finally disappears below the horizon, we should see the green fade away into blue and violet.

This I have actually observed at least twice, and I have no reason to doubt that it is visible at any time that the atmospheric conditions favour the appearance of a strong green flash.

In observing I used a Zeiss binocular, with a magnifying power of 12 diameters, and was careful to avoid eye fatigue by looking at the Sun only when a very small portion remained above the horizon. Under these circumstances the narrowing segment, which is, of course, of an orange-red colour, is first seen to turn green at its two extremities; the green colour then appears to run inwards until the whole area of the segment appears coloured.

whereas if it were a complementary
amount of previous gazing is absolut
well-authenticated appearance of th
rise (see *Nature*, vol. lx. p. 511, 18
Kelvin gives an account of its bein
Switzerland), when any retinal fati
The conditions favourable for its
be :—

1. An atmosphere free from haze a
of short wave length will be
green thus made faint or alt
2. A distant horizon, whether lan
as a dusty atmosphere is pra
sea, it is on the latter that t
noticed.

The distance of the horizon
If the air were perfectly fr
would be immaterial, withi
horizon is situated, but practi
as long a column of unillum
observer as possible, and ther
horizon the more likely is the
ance. I have, for instance,
with a land horizon at abou
have, under these circumstan
3. A still atmosphere and one homo
ture, or in other words condi
necessary for good "seeing"
the irregular dispersion of t
of the colours.

Condition No. 2 leads us up to the
able circumstances for seeing it —

# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. LXII. APRIL 11, 1902. No. 6


Dr. J. W. L. GLAISHER, M.A., F.R.S., PRESIDENT, in the Chair.

George Herbert Bryant, Higher Grade School, Cinderford, Gloucestershire;
Capt. G. P. Lenox-Conyngham, R.E., Survey of India, Mussoorie, India;
S. Alfred Mitchell, A.M., Ph.D., Columbia University, New York City, U.S.A.;
James Rankine, 11 West Saville Road, Edinburgh;
Thomas Thorp, Moss Bank, Whitefield, Manchester; and
William Boultbee Whall, Nautical Surveyor, Board of Trade, Liverpool,

were balloted for and duly elected Fellows of the Society.

The following Candidate was proposed for election as a Fellow of the Society:—

Henry Bridger Adames, 5 West Street, Chichester, Sussex (proposed by W. W. Bryant).



nando Observatory ; Lantern slid
Professor Rees and Mr. Post ; se
by the late John Brett, presented

---

*On the Relative Number of Star Im*
*Parts of a Plate, and on the P*
*Glasses in this respect.* By E
Savilian Professor.

1. If on a large number of plat
glass, and having a *réseau* impress
number of star images in each sq
together all the results for the same
to find that the total number for
Such a result would indicate that
field under survey in an ideally unif
we can only expect an approximati
we have had occasion to examine th
tion in the case of the object-glass u
graphic Chart photographs, and the
examination of the beautiful chart
Observatories taking part in this w
to draw attention to the general que

2. *The Oxford Object-Glass.*—A
character of the plate, the numbe
beginning measurement, and if
stars is found upon it another one
ditions. The counting is done by
number of stars in each row of 26 s

TABLE I.

*Counts of Outside Rows of 500 Oxford Plates expressed as Percentages of the Counts for the Middle Rows.*

| No. of Group. | Rows. | | | | | |
|---|---|---|---|---|---|---|
| | 0. | 25. | Mean. | 1. | 24. | Mean. |
| I. | 67 | 80 | 74 | 78 | 87 | 82 |
| II. | 74 | 81 | 77 | 83 | 89 | 86 |
| III. | 83 | 75 | 79 | 90 | 83 | 86 |
| IV. | 81 | 63 | 72 | 96 | 81 | 88 |
| V. | 88 | 99 | 94 | 96 | 99 | 98 |
| Mean of 500 | 79 | 79 | 79 | 89 | 88 | 88 |

Thus the extreme outside rows contain 20 per cent. fewer stars than the middle rows, and the next rows within them 12 per cent. less, on the average. But the individual discrepancies are large, and Group V. is specially noticeable as being quite different from the others. No reason could be assigned at the time for the exceptional character of Group V., and a more extended investigation was undertaken. We shall presently see that, as a result of the detailed inquiry, it is possible to assign a reason for the discrepancies (see § 14).

3. For the extended investigation the *measures* of 180 plates (zone $+25°$) were tabulated. In counting the plates, as above, they are passed under review rather rapidly, and sometimes faint stars are passed over; but in measuring a plate each square is carefully examined twice at least, and such omissions should be rare.

4. In Table II. are given the total number of stars in each square of the *réseau* for the 180 plates. The total number of stars is 46,825, which gives an average of 260 per plate. If we exclude the outside rows, so as to include an area $2° \times 2°$, the total is 41,437, and the average 230. Certain features of the object-glass may be seen by inspection. The number of stars falls off rapidly near the edges of the plate, *and also near the centre*, being a maximum about 30′ from the centre. But the accidental irregularities are still very large, even in the mean of 180 plates. To smooth these out the mean of every three adjacent numbers in $x$ was taken, and then the mean of every three adjacent in $y$; so that the final result, tabulated in Table III., is the mean of a group of nine, of which the element in question forms the centre.

TABLE

*Counts of Stars in each Réseau Square on* 180 *Plates with*

| 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|
| 48 | 49 | 35 | 56 | 59 | 61 | 69 | 77 | 67 | 83 | 61 |
| 44 | 60 | 54 | 60 | 64 | 63 | 60 | 63 | 89 | 69 | 75 |
| 42 | 55 | 66 | 66 | 63 | 70 | 74 | 67 | 87 | 83 | 71 |
| 61 | 58 | 71 | 70 | 69 | 92 | 80 | 77 | 74 | 70 | 78 |
| 68 | 50 | 59 | 71 | 67 | 68 | 74 | 87 | 85 | 87 | 67 |
| 67 | 53 | 59 | 70 | 64 | 77 | 80 | 55 | 92 | 72 | 88 |
| 69 | 68 | 81 | 51 | 66 | 82 | 87 | 72 | 83 | 84 | 70 |
| 80 | 81 | 84 | 70 | 79 | 70 | 91 | 85 | 78 | 69 | 52 |
| 73 | 79 | 79 | 80 | 83 | 78 | 72 | 82 | 80 | 75 | 78 |
| 62 | 75 | 71 | 77 | 77 | 87 | 58 | 74 | 64 | 70 | 60 |
| 63 | 70 | 77 | 87 | 70 | 69 | 64 | 77 | 69 | 63 | 75 |
| 79 | 62 | 70 | 56 | 69 | 86 | 84 | 90 | 52 | 79 | 80 |
| 73 | 60 | 88 | 76 | 64 | 84 | 84 | 73 | 86 | 75 | 66 |
| 78 | 60 | 69 | 63 | 73 | 85 | 77 | 79 | 62 | 80 | 52 |
| 72 | 57 | 71 | 95 | 83 | 91 | 91 | 67 | 78 | 70 | 69 |
| 70 | 71 | 71 | 82 | 69 | 96 | 66 | 77 | 85 | 69 | 79 |
| 78 | 77 | 56 | 73 | 80 | 87 | 96 | 98 | 80 | 81 | 84 |
| 70 | 61 | 93 | 82 | 87 | 81 | 94 | 86 | 69 | 58 | 67 |

II.

*Centres +25°, taken at University Observatory, Oxford.*

| 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 64 | 69 | 57 | 60 | 52 | 61 | 66 | 52 | 42 | 51 | 55 | 39 | 42 | 57 |
| 70 | 68 | 66 | 75 | 64 | 48 | 75 | 65 | 63 | 63 | 43 | 40 | 39 | 60 |
| 63 | 56 | 75 | 60 | 61 | 54 | 58 | 65 | 60 | 56 | 65 | 36 | 53 | 62 |
| 81 | 74 | 79 | 69 | 77 | 59 | 82 | 80 | 67 | 74 | 53 | 38 | 54 | 69 |
| 90 | 67 | 76 | 72 | 79 | 79 | 85 | 51 | 68 | 77 | 57 | 59 | 35 | 68 |
| 83 | 89 | 94 | 56 | 74 | 75 | 67 | 72 | 73 | 76 | 59 | 70 | 60 | 71 |
| 81 | 94 | 75 | 80 | 92 | 74 | 68 | 63 | 82 | 74 | 84 | 61 | 70 | 74 |
| 73 | 64 | 80 | 66 | 73 | 75 | 62 | 71 | 73 | 70 | 75 | 72 | 65 | 72 |
| 56 | 88 | 63 | 55 | 84 | 67 | 75 | 71 | 71 | 69 | 61 | 80 | 54 | 72 |
| 85 | 58 | 63 | 65 | 79 | 82 | 80 | 70 | 72 | 83 | 61 | 79 | 57 | 71 |
| 69 | 76 | 77 | 86 | 73 | 77 | 74 | 74 | 79 | 72 | 58 | 69 | 59 | 71 |
| 71 | 84 | 61 | 80 | 85 | 56 | 76 | 82 | 76 | 85 | 72 | 71 | 61 | 74 |
| 70 | 73 | 85 | 70 | 78 | 84 | 71 | 63 | 65 | 70 | 81 | 62 | 64 | 72 |
| 67 | 87 | 59 | 84 | 84 | 74 | 82 | 100 | 78 | 75 | 84 | 64 | 56 | 73 |
| 82 | 67 | 57 | 55 | 67 | 88 | 97 | 77 | 100 | 72 | 67 | 71 | 50 | 75 |
| 61 | 79 | 77 | 69 | 69 | 79 | 74 | 86 | 87 | 98 | 73 | 75 | 54 | 75 |
| 75 | 66 | 65 | 66 | 85 | 84 | 88 | 85 | 72 | 73 | 66 | 70 | 51 | 76 |
| 68 | 72 | 97 | 96 | 85 | 76 | 84 | 79 | 78 | 72 | 81 | 77 | 59 | 78 |
| 75 | 78 | 87 | 74 | 83 | 93 | 72 | 76 | 100 | 69 | 56 | 68 | 67 | 76 |
| 78 | 83 | 87 | 89 | 75 | 72 | 74 | 72 | 80 | 59 | 77 | 54 | 53 | 74 |
| 76 | 83 | 65 | 73 | 87 | 74 | 60 | 66 | 70 | 72 | 63 | 61 | 46 | 71 |
| 78 | 60 | 85 | 82 | 72 | 73 | 62 | 62 | 45 | 60 | 58 | 65 | 49 | 68 |
| 74 | 88 | 77 | 77 | 82 | 71 | 65 | 66 | 72 | 54 | 85 | 51 | 56 | 72 |
| 83 | 72 | 78 | 64 | 69 | 63 | 98 | 62 | 50 | 47 | 45 | 36 | 34 | 60 |
| 72 | 79 | 62 | 73 | 72 | 70 | 62 | 52 | 62 | 44 | 48 | 40 | 33 | 58 |
| 68 | 72 | 55 | 74 | 66 | 61 | 62 | 48 | 44 | 36 | 52 | 32 | 38 | 53 |
| 74 | 75 | 73 | 72 | 76 | 72 | 74 | 70 | 70 | 67 | 65 | 59 | 52 | 69 |

III.

*of which the Central Element is indicated by the arguments given.*

| 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 71 | 66 | 65 | 65 | 63 | 60 | 60 | 60 | 61 | 58 | 55 | 50 | 46 |
| 73 | 71 | 70 | 69 | 69 | 63 | 64 | 65 | 68 | 66 | 60 | 52 | 47 |
| 77 | 73 | 74 | 70 | 72 | 68 | 70 | 68 | 68 | 66 | 64 | 57 | 50 |
| 80 | 80 | 82 | 75 | 75 | 71 | 75 | 72 | 72 | 71 | 67 | 63 | 54 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | — | — | 70 | 71 | 72 | 73 | 73 |
| 12 | 71 | 72 | 71 | 67 | 70 | 73 | |
| 13 | 69 | 68 | 70 | 71 | 76 | 79 | |
| 14 | 70 | 70 | 69 | 71 | 75 | 82 | |
| 15 | 70 | 72 | 69 | 73 | 75 | 84 | |
| 16 | 68 | 72 | 73 | 74 | 77 | 82 | |
| 17 | 67 | 72 | 76 | 75 | 78 | 80 | |
| 18 | 64 | 71 | 76 | 78 | 79 | 76 | |
| 19 | 60 | 69 | 73 | 75 | 74 | 74 | |
| 20 | 58 | 65 | 66 | 70 | 70 | 74 | |
| 21 | 55 | 64 | 67 | 70 | 68 | 76 | |
| 22 | 48 | 58 | 60 | 66 | 65 | 71 | |
| 23 | 45 | 53 | 56 | 60 | 60 | 65 | |
| 24 | 39 | 44 | 46 | 51 | 57 | 60 | |

5. Even in the smoothed Table III.
ties. The northern half of the plate (la
than the southern; but this is almost
peculiarity of the object-glass, but to th
the sky. The general features of this d
paper by Mr. Bellamy in *Monthly N*
glance at the middle diagram given b
opposite p. 16) will show that for the
$17^h - 24^h$ the number of stars about de
as we go north; and for the region $6^h$
indifferent. A smaller inequality in $x$ i
cause. To eliminate this effect, and st
object-glass alone, we may add togeth
situated on opposite sides

| 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 81 | 83 | 78 | 78 | 76 | 77 | 70 | 70 | 71 | 72 | 69 | 62 |
| 75 | 77 | 81 | 77 | 77 | 74 | 74 | 70 | 70 | 73 | 74 | 71 | 69 |
| 71 | 73 | 75 | 74 | 74 | 74 | 74 | 69 | 70 | 71 | 73 | 72 | 69 |
| 68 | 68 | 70 | 67 | 70 | 72 | 75 | 73 | 72 | 72 | 71 | 72 | 67 |
| 70 | 72 | 71 | 70 | 72 | 74 | 77 | 74 | 74 | 74 | 70 | 70 | 64 |
| 73 | 73 | 72 | 72 | 74 | 76 | 75 | 75 | 76 | 77 | 73 | 72 | 65 |
| 72 | 74 | 74 | 77 | 76 | 75 | 74 | 73 | 73 | 74 | 73 | 71 | 66 |
| 71 | 72 | 73 | 76 | 76 | 77 | 76 | 76 | 77 | 77 | 76 | 74 | 68 |
| 70 | 70 | 72 | 71 | 71 | 76 | 80 | 82 | 81 | 78 | 77 | 72 | 67 |
| 70 | 72 | 71 | 70 | 69 | 74 | 79 | 84 | 87 | 86 | 82 | 76 | 66 |
| 74 | 74 | 70 | 67 | 67 | 73 | 81 | 84 | 85 | 83 | 79 | 74 | 64 |
| 74 | 72 | 73 | 76 | 79 | 79 | 81 | 82 | 81 | 81 | 78 | 76 | 67 |
| 78 | 77 | 76 | 78 | 82 | 82 | 83 | 82 | 81 | 78 | 74 | 70 | 66 |
| 78 | 79 | 81 | 85 | 86 | 82 | 79 | 78 | 80 | 76 | 75 | 68 | 66 |
| 80 | 82 | 79 | 80 | 80 | 80 | 77 | 73 | 74 | 74 | 72 | 64 | 60 |
| 79 | 78 | 77 | 78 | 79 | 77 | 72 | 68 | 66 | 65 | 65 | 63 | 58 |
| 79 | 74 | 76 | 77 | 78 | 77 | 72 | 67 | 63 | 63 | 64 | 63 | 59 |
| 78 | 77 | 77 | 76 | 76 | 72 | 73 | 69 | 65 | 58 | 58 | 56 | 53 |
| 77 | 80 | 76 | 74 | 72 | 71 | 73 | 68 | 65 | 56 | 56 | 50 | 47 |
| 73 | 77 | 71 | 70 | 68 | 68 | 69 | 64 | 60 | 49 | 47 | 42 | 40 |

table (Table IV.). A word of explanation may first be given as to the formation of the results for these other object-glasses.

6. *The Paris, Algiers, Toulouse, and San Fernando Object-Glasses.*—Some of the long exposure plates for the Astrographic Chart, taken at these Observatories, have recently been beautifully reproduced by heliogravure, and copies presented to the University Observatory, Oxford, among other observatories. On these copies counts of the number of stars in each square of the diagonals have been made, and the results for the four squares equidistant from the centre added together. It must be remembered that the results are not strictly comparable with those for Oxford plates, the exposures being quite different; so that the loss of stars on the paper charts depends on the increase of stellar density with magnitude near magnitude 14, while for the Oxford plates it is the density near magnitude 11, which may be quite different. It does not appear, however, that the difference is of serious importance for our present purpose. The number of charts counted varies somewhat. From San Fernando only ten charts have been received, and these were all counted. For Paris thirty charts and for Algiers twenty charts seemed to be sufficient to show the features of the distribution clearly; but in the case of Toulouse the results were rather

nd the counting was extended to forty charts for Ultimately, as will presently be explained, the e different plates were all satisfactorily accounted thesis which is at least a *possible* one. The results nt Observatories are given in Table IV.

TABLE IV.

*Stars in "Réseau" Squares lying along the Plate-Diagonals, for Various Observatories.*

| Observatory. | | | | |
|---|---|---|---|---|
| Oxford (180 plates). | Paris (30 plates). | Algiers (20 plates). | Toulouse (40 plates). | San Fernando (10 plates). |
| 255 | 157 | 133 | 228 | 68 |
| 300 | 154 | 145 | 228 | 64 |
| 308 | 173 | 131 | 223 | 66 |
| 303 | 166 | 129 | 248 | 51 |
| 335 | 176 | 148 | 244 | 59 |
| 307 | 214 | 144 | 247 | 61 |
| 276 | 199 | 177 | 238 | 42 |
| 262 | 195 | 152 | 190 | 68 |
| 223 | 242 | 135 | 175 | 46 |
| 272 | 220 | 140 | 153 | 44 |
| 206 | 187 | 128 | 122 | 42 |

centre of the field, that at a distance $r$ from the centre is $y = Ar^2$ nearer the object-glass than $F_0$. Let the plate cut the curve of best focus at Q, where

$$QM = y_0 = Ar_0^2.$$

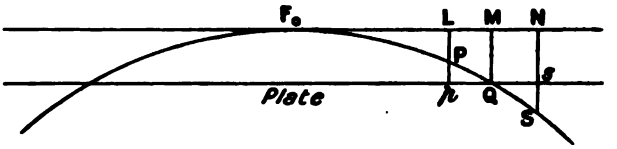



FIG. 1.

Now let us suppose that if we had a curved plate $F_0PQ$ we should get the star density uniform, and that the loss of stars is proportional to the distance of the plate from this surface. Then the density at Q will be $a$, say, and at P, $a - b \cdot Pp$.

But $$Pp = QM - PL = A(r_0^2 - r^2),$$

$\therefore$ density at P is $$a - Ab(r_0^2 - r^2).$$

When $r > r_0$ we must change the sign of the term in the bracket. In fact the density may be written

$$D = a\{1 \sim c(r^2 - r_0^2)\}$$

10. This hypothesis is only put forward as illustrative; the two main assumptions may be only the roughest approximations; but it seems to fit the facts tolerably well even with a constant value of $c$ for all the five objectives; so that there is something to be said for it. To find the value of $c$ we will take from inspection of Table IV. the following rough values of $r_0$ and the corresponding extreme values of the density.

TABLE V.

| Observatory. | $r_0$. | D when $r$ is 0′. | $r_0$. | 90′. | $r_0^2$. | $(90^2 - r_0^2)$. | $c'_1$. | $c'_2$. |
|---|---|---|---|---|---|---|---|---|
| Oxford ... ... | 32′ | 260 | 335 | 160 | 1024 | 7076 | 220 | 74 |
| Paris ... ... | 60 | 157 | 242 | 100 | 3600 | 4500 | 98 | 131 |
| Algiers ... ... | 46 | 133 | 177 | 75 | 2116 | 5984 | 117 | 97 |
| Toulouse ... | 32 | 228 | 250 | 75 | 1024 | 7076 | 86 | 99 |
| San Fernando ... | 0? | 68 | 68 | 31 | 0 | 8100 | ... | 68 |

Since when $r = r_0$ the value of D is $a$, and when $r = 0$ it is $a(1 - cr_0^2)$, the difference divided by $ar_0^2$ gives a value of $c$ which we may call $c_1$. And similarly putting $r = 90'$, and comparing with $r = r_0$, we get a value of $c$ which we may call $c_2$. In the table these values multiplied by $10^6$ are given under the heads $c'_1$ and $c'_2$. The mean of the values of $c'_1$ is 130, and of $c'_2$ 94,

is determined from rather better divisors. We fair assumption $c' = 100$ ; and thus

$$c = 100 \div 10^6 = 10^{-4}.$$

if a plate were placed so that its *centre* was at the number of stars would fall off at various distances e, as below, taking for simplicity $a = 100$ :

| | | | | | |
|---|---|---|---|---|---|
| centre ... | 0′ | 20′ | 40′ | 60′ | 80′ |
| stars ... | 100 | 96 | 84 | 64 | 36 |

$2^2$, $4^2$, $6^2$, &c. But if the plate be put within the he best focus is 20′ from the centre the numbers

| | | | | | |
|---|---|---|---|---|---|
| centre ... | 0 | 20′ | 40′ | 60′ | 80′ |
| stars ... | 96 | 100 | 88 | 68 | 40 |

g adopted a value of $c$ it becomes possible to ther more accurate value of $r_0$ for each Observa- ocess is as follows : Suppose we assume any value rd $> 31'{\cdot}8$ and $< 38'{\cdot}9$ (*i.e.* between the 5th and the first column of Table IV.), say 35′. Then $0^{-4} \times 100 = 12$.

Forming $r^2 \times 10^{-4} \times 100$ as in the second column of Table VI., and the difference from 12, we subtract this from 100 to get $C_1$. The mean value of $C_1$ is 78; and the mean value of the column for Oxford in Table IV. is 262. The factor 78/262 or ·298 serves to reduce the Oxford column of Table IV. to the column $O_1$ of Table VI.; and $O_1 - C_1$ shows how far we have satisfied the observations. The residuals are negative at first, positive later. Now the value of $r_0$ is to be adjusted. We have subtracted $acr_0^2$ from the first five groups in $C_1$, and added it to the last 8. We can improve the residuals then by increasing $acr_0^2$. Let us increase it by $x$. Then so long as $x$ is not greater than 3 the principal effect is to diminish the first five groups by $x$ and increase the last 8 by $x$. (There is a subsidiary effect arising from the change in the mean value of $C_1$; but this is small, and we may neglect it if the first approximation is good.) Hence changing the sign of the first 5 and adding to the last 8, which gives +27, we may equate this to $13x$ and get $x = +2{\cdot}3$. The effect on the mean value of $C_1$ is negligible, and thus $O_2 = O_1$.

13. The residuals, however, do not show much improvement, if any, and the determination of $r_0$ is clearly not a very exact operation. But in this way sufficiently good values of $r_0$ have been found for the different Observatories as follows:

TABLE VII.

| Dist. from Centre. | Paris. $r_0 = 58''{\cdot}3$. $acr_0^2 = 34$. | | Algiers. $r_0 = 49''{\cdot}0$. $acr_0^2 = 24$. | | Toulouse. $r_0 = 30''{\cdot}0$. $acr_0^2 = 9$. | | San Fernando. $r_0 = 34''{\cdot}6$. $acr_0^2 = 12$. | |
|---|---|---|---|---|---|---|---|---|
| | C | O−C | C | O−C | C | O−C | C | O−C |
| 3·5 | 66 | + 1 | 76 | +2 | 91 | +1 | 88 | +14 |
| 10·6 | 67 | − 1 | 77 | +8 | 92 | 0 | 89 | + 8 |
| 17·7 | 69 | + 5 | 79 | +2 | 94 | −4 | 91 | + 9 |
| 24·7 | 72 | − 1 | 82 | −6 | 97 | +3 | 94 | −17 |
| 31·8 | 76 | 0 | 86 | +1 | 99 | 0 | 98 | − 9 |
| 38·9 | 81 | +11 | 91 | −6 | 94 | +6 | 97 | − 5 |
| 46·0 | 87 | − 2 | 97 | +7 | 88 | +8 | 91 | −28 |
| 53·0 | 94 | −10 | 96 | −6 | 81 | −4 | 84 | +18 |
| 60·1 | 98 | + 6 | 88 | −8 | 73 | −2 | 76 | − 7 |
| 67·2 | 89 | + 5 | 79 | +3 | 64 | −2 | 67 | − 1 |
| 74·2 | 79 | + 1 | 69 | +6 | 54 | −5 | 57 | + 6 |
| 81·3 | 68 | − 2 | 58 | +3 | 43 | +1 | 46 | + 5 |
| 88·4 | 56 | −11 | 46 | 0 | 31 | +2 | 34 | +13 |

Figures 2, 3, 4, and 5 illustrate these results diagrammatically.

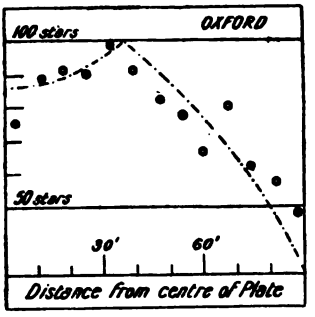



FIG. 2.

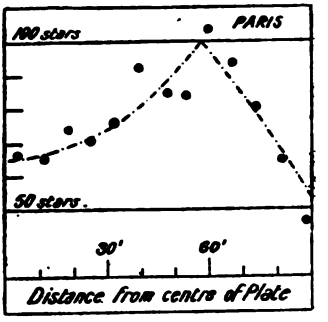



FIG. 3.

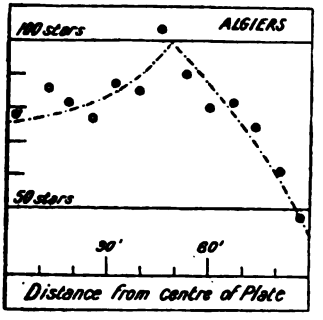



FIG. 4.

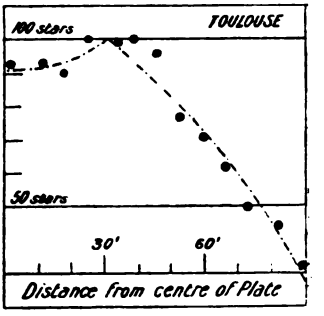



FIG 5.

14. It will be seen from the values of O—C that this rough but simple assumption fits all the facts tolerably well. And there is another observed fact which it will explain equally well. Returning to § 2, it was remarked that the counts of rows on different plates were not consistent. Group V. in Table I. is different from the other groups. Now if the performance of an object-glass be regarded as constant, and if this were the only factor involved, we might find it puzzling to explain such a change. We should have to refer it to errors of counting in some way. But on the present assumption, that apparent differences in performance of the object-glass are mainly due to different positions of the plate within the principal focus, we have an obvious method of explaining the differences in the groups of Table I. It seems probable that the plate-holder has been put back in a slightly different position, and so the outside rows, instead of being deficient compared with the central, as in the earlier groups of Table I., and as shown by the means of rows in Table II., are nearly equal to them. If this is the case our general rule tells us that the new position of the plate must be nearer the object-glass, so that the maximum falls farther from the centre than in Table II.

15. To test this the numbers for other rows of the plates in Group V. were formed; and also for Group I., as a general check. Reduced to percentages they were found to be as follows, rows 0 and 25, 1 and 24, &c., being combined to eliminate the effect of non-uniform star distribution:

TABLE VIII.

| | 0 and 25 | 1 and 24 | 2 and 23 | 3 and 22 | 4 and 21 | 5 and 20 | 6 and 19 | 7 and 18 | 8 and 17 | 9 and 16 | 10 and 15 | 11 and 14 | 12 and 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Table II. | 80 | 85 | 90 | 100 | 98 | 102 | 105 | 105 | 108 | 107 | 105 | 108 | 103 |
| Group I. of Table I. | 81 | 86 | 92 | 100 | 101 | 103 | 109 | 106 | 104 | 104 | 104 | 104 | 106 |
| Group V. of Table I. | 91 | 94 | 100 | 102 | 106 | 104 | 102 | 106 | 100 | 102 | 101 | 98 | 97 |

In Table VIII. the first row refers to the plates in zone $+25°$ analysed in Table II. These were among the earliest plates taken and measured, and the counts are taken from the recorded measures. The second line refers to plates counted with the billiard-marker in 1898. The accordance with the first line is satisfactory, and it may be inferred that the object-glass was not sensibly disturbed up to 1898. But the third line is quite different, the maximum falling much further from the centre.

16. It must be remembered that the maximum is now *for a row* and not for a square, as formerly. Adopting the formula already given the theoretical count for a row, with any given value of $r_0$, is easily found; and the following results have been obtained, reducing to percentages as before:

TABLE IX.

*Value of* $r_0$.

| Values of $y$. | 0′ | 15′ | 30′ | 40′ | 50′ | 60′ |
|---|---|---|---|---|---|---|
| 12 or 13 | 86 | 87 | 89 | 89 | 85 | 78 |
| 11 „ 14 | 85 | 87 | 89 | 89 | 86 | 79 |
| 10 „ 15 | 84 | 86 | 89 | 89 | 86 | 79 |
| 9 „ 16 | 83 | 85 | 89 | 89 | 87 | 80 |
| 8 „ 17 | 81 | 83 | 88 | 89 | 88 | 82 |
| 7 „ 18 | 78 | 80 | 87 | 89 | 89 | 84 |
| 6 „ 19 | 75 | 77 | 84 | 89 | 89 | 85 |
| 5 „ 20 | 72 | 72 | 81 | 87 | 90 | 86 |
| 4 „ 21 | 68 | 70 | 77 | 84 | 89 | 87 |
| 3 „ 22 | 63 | 65 | 72 | 79 | 88 | 89 |
| 2 „ 23 | 58 | 60 | 67 | 74 | 83 | 89 |
| 1 „ 24 | 53 | 55 | 62 | 69 | 78 | 88 |
| 0 „ 25 | 47 | 49 | 56 | 63 | 72 | 83 |
| Average | 72 | 74 | 79 | 83 | 85 | 84 |

rcentages given above are not quite similar to those
fore, when 100 has been assigned as the mean value
counts of actual plates we had no means of know-
standard was; but in the above table it was sup-
ideal number for each square (reached only at
on the circle of exact focus) was 100, as in
VII.; and we thus see that on the whole fewest
hen $r_0$ is about 50′. At Paris the plate is rather
the focus from this point of view; at other
not far enough.

chief interest of Table IX. lies in its comparison
II. We see that the first two lines of Table VIII.,
ximum is not very definite, accord very well with
ble IX., as we have had independent reason to ex-
third line in Table VIII. is much better suited by
rhaps by a rather larger value than this even.
position that the plate-holder was not put back
ld position seems to be confirmed.

be obvious that care must be exercised in making
cerning ($a$) the number of stars in a given region,
udes of stars in different parts of the plates,
ne focal adjustments have been changed at any
t proposed to dwell on the details here; rather to
to the matter generally. It may be considered
ties discussed in this paper are not serious; but
something like 50 per cent. in number of stars,
ords, about a whole magnitude, and I cannot but
y must be reckoned with in any exhaustive dis-
photometric or distributive

TABLE X.

*Cape Photographic Durchmusterung.*

| Zone. ° | 0m and 19m | 1m and 18m | 2m and 17m | 3m and 16m | 4m and 15m | 5m and 14m | 6m and 13m | 7m and 12m | 8m and 11m | 9m and 10m |
|---|---|---|---|---|---|---|---|---|---|---|
| −19 | 101 | 98 | 104 | 96 | 99 | 101 | 102 | 100 | 102 | 97 |
| −20 | 108 | 94 | 93 | 102 | 105 | 97 | 103 | 99 | 105 | 95 |
| −21 | 100 | 111 | 100 | 94 | 96 | 101 | 99 | 104 | 97 | 98 |
| −22 | 100 | 100 | 98 | 102 | 99 | 100 | 104 | 104 | 101 | 90 |
| −23 | 102 | 103 | 104 | 99 | 96 | 104 | 97 | 98 | 97 | 99 |

21. These numbers, which are in some ways comparable with numbers occurring in earlier paragraphs of this paper, give a high character for uniformity to the objective used for the C.P.D. The numbers in the last column in Table X. are all less than 100, and those in the first column alone never fall below 100. But beyond this bare fact the columns are distinctly comparable. We have no real discrepancies, approaching 50 per cent., such as have been discussed in the earlier paragraphs of this paper.

22. Have we been right to take the single objective, rather than the photographic doublet, for star-charting? The question has forced itself upon our attention in a number of ways since the decisive step was taken in 1887. It certainly seems, from the discussion in the present paper, that as regards getting a uniform scale of magnitudes over a large area, the doublet is immensely superior to the single objective. Over a field 2° square the latter is obviously defective; over a field 6° square the former gives excellent results. For accurate *positions* of stars the latter *may* be superior (this has yet to be established). But for charting? for the long-exposure plates, which are possibly not intended for the determination of exact positions? To take these long-exposure plates in such small areas as $2° \times 2°$ is immensely laborious; and if they are comparatively defective as well is it even yet too late to reconsider the decision of 1887?

## *Summary.*

As a general summary of this paper the following points may be enumerated:—

A. Counts of star images on plates taken at Oxford (exposure 3m) and at Paris, Algiers, Toulouse, and San Fernando (exposure 30m) show that the density of stars photographed in different parts of the plate varies by about 50 per cent.

B. The region of greatest density is not the centre of the plate, but a ring which may be of 35′ (Toulouse, San Fernando, Oxford), 50′ (Algiers), or even 60′ (Paris) radius; in the last

ty at the centre of the plate is only 0·66 of the
sity.
fferences between these five Observatories may be
the hypothesis that the plate is put at different
in the focus, and without assuming any essential
he objectives.
notographic doublet used for the C.P.D. gives a
rm field over 6° × 6°. The question arises, have
est instrument for *star-charting*, seeing that it is
have uniformity of magnitude over the field

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*tationary Meteor Radiants. Third Paper.*

H. Turner, D.Sc., F.R.S., Savilian Professor.

*thly Notices*, lix. p. 140, it was suggested that the
racter claimed for certain radiants by Mr. W. F.
other observers might be explained by the cumula-
he Earth's attraction on members of the swarm
near it at successive returns. It was shown how
might retain the direction of their velocity relative
(and therefore their radiant), and yet meet the
n its orbit at successive returns. In this way the
originally compact swarm would no longer follow
e orbit round the Sun, but would be distributed

3. If it should turn out that meteoric velocities are usually sensibly smaller than parabolic it would be more favourable to this explanation; and accordingly my attention was arrested by the results of the photographic determinations of velocity made at the Yale Observatory, which indicate unexpectedly small velocities so far as they go. The account of these experiments which I have seen is a short paper by Dr. Elkin, read at the second meeting of the Astronomical and Astrophysical Society of America (reprinted from *Science*, N.S., xii. pp. 121–129). Five trails were observed, of which one was an *Andromedid*, and was presumably moving in the track of Biela's comet. The observed relative volocities were *not* parabolic, as is seen by the following comparison:

| Meteor No. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Observed *Relative* Velocity (km. per sec.) | 49·1 | 5·0 | 49·0 | 16·8 | 34·7 |
| Theoretical Value | 58·3 | 27·1 | 60·3 | 19·6 | 49·5 |

No. 4 is the *Andromedid*, and the theoretical velocity is calculated from the orbit of Biela's comet, the others for sensibly parabolic orbits.

4. Dr. Elkin's criticism of these results is:—"The observed velocities lead to orbits of a very improbable character having periods of from 1·25 to 1·80 years, so that it would seem an almost certain conclusion that the atmospheric retardation has amounted to from eight to fifteen km. per sec. for the four meteors."

5. Now, firstly, without laying too much stress on these few observations, I would ask, *Why* are orbits of 1·25 to 1·80 years' period of a "very improbable character"? Merely because of the novelty of the idea? To me it seems, on the other hand, more in harmony with the general habits of the solar system that many of the meteors we encounter should be revolving round the Sun in nearly circular orbits, in which case they would have just such periods.

6. Secondly, if (as Dr. Elkin admits is possible) further evidence shows these smaller velocities to be "somewhere near the cosmic values," then the time required to develop a "stationary radiant" on the lines I have suggested is much shortened. In the first paper (*Monthly Notices*, lix. pp. 148, &c.) it is shown that if

T be the time spent within the Earth's sphere of influence,
$e$ the eccentricity of the hyperbola described relative to the Earth,

and if $f = 1/(e-1)$, then the "time-gain" may be about $fT/23$.

Now, if the relative velocity of approach to the Earth is diminished, both $f$ and T are diminished—$f$ because the hyperbola described relative to the Earth is more curved, and $e$ is

; and T because the meteor is moving relatively
nd stays longer in the sphere of influence.
or meteors No. 1 and No. 3 of the above series of
ative velocity forty-nine km. per sec.) the time-gain
n is only about one minute : and it would take at

$60 \times 24 \times 365 = 525,600$ encounters

ie swarm completely round the Earth's orbit, *i.e.*
ny million years. But for meteor No. 5 this time
duced approximately in the ratio $(35/49)^2 = 1/2$ ;
in the ratio $(5/49)^2 = 1/100$.
is to the suggestion of atmospheric retardation, or
sion of this suggestion, that I wish in the present
w particular attention. In its ordinary form this
e familiar to meteor observers, who notice sometimes
p" of the meteors observed, doubtless due to the
h we know to be large enough to cause their
Mr. Denning writes in a letter to me :
case of certain long-pathed meteors which I have
process of 'slowing-up' has been most marked, and
ed a few meteors which almost came to a standstill
their apparent flights."
how far away from the Earth does this "slowing-up"
at is to say, how far does an atmosphere capable of
meteor's flight, however slightly, extend ? We are
o think of the atmosphere as only a few hundred
t most ; but this notion is derived from phenomena

is requisite. He considers it an established fact that there is sensibly no helium in our atmosphere (recent results show that this is not the case), and concludes that a velocity of nine times the mean is reached sufficiently often to allow of all the helium escaping. From this he argues for other planets, *e.g.* that there is no water on *Mars*. But without following him further, let us consider the idea of a molecule escaping when it happens to have a velocity nine times the mean. Now, however many molecules there may be with this velocity, there must be more with velocities slightly less, say eight times the mean. What happens to these? Clearly in similar cases they will describe orbits which are very large ellipses with the Earth in one focus, just as material particles would. There must, again, be more molecules still with a velocity seven times the mean, and they would describe rather smaller ellipses, and so on. In fact we get a conception of an atmosphere extending a very long way, where the molecules cease to behave like a gas and behave more like satellites. We have scarcely data for forming even a rough guess at the probable resistance this atmosphere might offer at (say) 1000 miles from the Earth's surface to the motion of a small body like a meteor; but there does not seem anything impossible in the supposition that the effect might be sensible.

11. Assuming then that in the neighbourhood of the Earth there may be a resisting medium, however tenuous, what would be the effect on the orbit of a meteor passing near the Earth? By "reducing the Earth to rest," as before, we get the simple case of the meteor, now moving with its velocity *relative to the Earth* only, passing temporarily through a slightly resisting medium. Hence

(1) The velocity (*i.e.* relative velocity) will be slightly diminished in magnitude.

(2) It will not be altered in direction. Further,

(3) On leaving the resisting medium the meteor will, owing to the diminution of velocity, be slightly *behind* the place it would have otherwise occupied; there is a *delay*, of the same kind as the *acceleration* due to the Earth's attraction.

12. In fact these effects are almost precisely those which have been already shown (in the case of the Earth's attraction) to produce a "stationary radiant." No. 2, the constancy of the velocity in *direction* means that the radiant is unaltered; and No. 3, the slight delay, means that the meteor is encountered by the Earth slightly *later* on the next return; so that by cumulative action at successive returns some meteors might be gradually spread along the Earth's orbit, with a constant radiant.

13. There are, however, two important new features in this action of a resisting medium as compared with that of the Earth's attraction. First, the relative velocity of the meteor is diminished each time it passes through the medium, and hence will diminish continually. This is a distinct gain as compared with our former explanation of stationary radiants, for in that the relative velocity

was left unaltered in magnitude, and this is not in accordance with observed facts (see *Monthly Notices*, vol. lix. p. 146). But, secondly, when we come to calculate quantitatively the possible *amount* of spreading of the shower, due to the delay, we find it strictly limited in amount, and such as will not explain any long duration of a stationary radiant.

14. Let $v$ be the velocity with which the meteor enters the resisting medium at any return, and $v+dv$ that with which it leaves, $dv$ being of course negative. Let $v_0$ be the original velocity and T the original time spent in the medium, so that the space traversed is $v_0T$. The time of traversing this space with velocity $v$ is $v_0T/v$; and if the velocity $v$ change uniformly to $v+dv$ during the traverse, the time spent will be $v_0T/(v+\frac{1}{2}dv)$, so that the delay at this particular return is $-\frac{1}{2}v_0T\frac{dv}{v^2}$. The total delay occasioned by a change from the original velocity $v_0$ to $v_1$ is thus

$$-\tfrac{1}{2}v_0T\int_{v_0}^{v_1}\frac{dv}{v^2}=\tfrac{1}{2}\cdot\frac{v_0-v_1}{v_1}\cdot T.$$

15. Now the factor $(v_0-v_1)/v_1$ may theoretically be made as large as we please by diminishing $v_1$ sufficiently; but in practice it does not seem likely that it would be large. Taking, for example, the velocities observed at Yale as in §3, the largest value of $(v_0-v_1)/v_1$ is that for meteor 2, where $v_0=27{\cdot}1$ and $v_1=5{\cdot}0$; so that $(v_0-v_1)/v_1=4{\cdot}4$. If, further, we suppose the meteor to be originally within the resisting medium for 270,000 kilometres, or 10,000 seconds, which seems an extreme supposition, we get T = 10,000 sec. = 3 hours about, so that the total "delay" is less than seven hours. For the formation of a "long-enduring" radiant this quantity (which probably represents an extreme limit in every way) is negligible.

16. Hence the effect of the resistance of the Earth's atmosphere, though it is of the same kind as that of the Earth's attraction in many respects, is not indefinitely cumulative, and is in fact limited to a total amount which is negligible. The resistance of the atmosphere cannot be the *sole* cause of a stationary radiant.

17. But it may be a *contributing* cause. Those meteors which are subjected to the possible retardation of the atmosphere by hypothesis pass near the Earth and are subject to its attraction, as before considered, and *vice versa*. In fact we must consider the effect of *both causes conjointly*. Now the latter (the Earth's attraction) alone can be responsible for any great spreading action; but in another feature the effect of the former (atmospheric resistance) is the more important, viz. in the change of relative velocity.

18. It has been shown in the earlier papers that the Earth's attraction leaves the relative velocity of the meteors unchanged. But in § 11 it has been remarked that the atmospheric retardation

continually diminishes this relative velocity. Is this the source of the difference in velocities of meteors from the same stationary radiant observed by Mr. Denning? We must first remark which meteors will be most affected: obviously those which have been subjected to the atmospheric retardation, and therefore also to the Earth's attraction, most often and most severely. From the operation of the second cause these will be meteors encountered *earliest* in the Earth's journey through the series of showers—*i.e.* the Earth should meet slow meteors first and quick ones later. Now Mr. Denning's observed rule is quite different, at any rate in form. He says: "The meteors from showers which are moving in an opposite direction to the Earth are generally much swifter than meteors travelling with the Earth." The two rules could not agree completely; but the observed facts might by chance satisfy both. To test this I wrote to Mr. Denning for some examples, asking him whether slow meteors came early in the encounter with the radiant and quick ones late. He promptly replied (1902 March 15) by some examples which do *not* fall in with the suggested rule, and the suggested explanation falls through. One or two of the examples may be given:—

*Radiant* 23°+44°. *G.C. xxi.* $\gamma$ *Andromedids.*—Meteors very swift with streaks in July and August; in September rather swift; in October slow, and in November very slow.

*Radiant* 30°+36°. *G.C. xxv.* $\beta$ *Triangulids.*—Meteors very swift with streak in July and August; in September rather swift; in October swift; in November and December slow and trained.

*Radiant* 63°+21°. *G.C. liii.* $\epsilon$ *Taurids.*—Motion very rapid in August and September; in October rapid; in November slow. The same may be said of a bordering shower of *Taurids* from a radiant of about 57° +9°.

*Radiant* 61°+49°. *G.C. lvi.* $\mu$ *Perseids.*—Very swift in July, August, September, and November.

*Radiant* 270°+24°. *G.C. ccv. Herculids* (97).—Meteors very swift with streak in April; slow in July and August.

*Radiant* 296°+1°. *G.C. ccxxx.* $\eta$ *Aquilids.*—Meteors very swift with streak in April and May; slow and very slow in July and August.

19. It thus seems clear that no improvement in the theory already advanced is afforded by considerations of atmospheric retardation, except in the sense indicated in §§ 6 and 7—*i.e.* that the development of a long-enduring radiant may not take so long. But, as the question of atmospheric retardation arises naturally in connection with this question of the Earth's attraction, this examination of the point may as well be put on record, although the general result is negative.

### *General Conclusion.*

In connection with a theory of stationary radiants of meteors as due to the attraction of the Earth, advanced in former papers

*tices*, lix. p. 140 and lx. p. 450), the question of ospheric retardation of meteors passing near the en examined. This retardation is suggested by the es observed by Elkin ; and if such small velocities be the rule the time required to establish a long- ant on the lines already suggested is curtailed. The retardation may also itself exercise a spreading radiant of the same kind as that exercised by the ction, but so small in amount as to be negligible, panying effect on the relative velocity is apparently ance with observed facts.

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*omalous Occultation of Stars by the Moon.*
By G. W. Hough.

(*Communicated by the Secretaries.*)

*onthly Notices* for 1901 April Mr. R. T. A. Innes l an article on anomalous occultations ; and subse- umber of communications, on the same topic, by d others have appeared in the Observatory.

ect is one of considerable interest in its bearing on of double stars, due to the abnormal phenomena e observed.

he past four years I have observed nearly 300 with the 18½ inch refractor of the Dearborn

The failure to see the real phenomenon was due to insufficient optical power, as will readily appear from the observations which follow. A small telescope and low power will not exhibit the phenomenon in the same manner as an instrument of greater power.

Double stars like *Antares*, or, in fact, all double stars, in which the components are not very unequal, and the distance not less than 2″, may be seen and recorded separately by the use of optical power equal to that I have employed.

I append such examples from my list of observations :—

1898 February 23. Σ67 8·2—9·1 mag. $p = 7°$ $s = 1''.86$.
"Companion disappeared $1^s$ later."

1898 June 30.
« *Scorpii* 1—8. mag. $p = 271°.9$ $s = 3''.13$.
"Companion disappeared $4^s.8$ earlier."

1900 January 7. Σ 67 $p = 7°$ $s = 1''.86$.
"Companion disappeared $6^s.94$ later."

In (*A.J.*) 488 I have published a list of 193 occultations. Two interesting cases of abnormal phenomena were noted.

1897 March 3. 7·5 magnitude star. "Suddenly diminished to one-half brightness before disappearance." This star was subsequently identified as Ho 247. 87·22 $p = 101°.3$ $s = 0''.36$ 7·5—8 magnitude. A very close double.

(*A.J.*) 474. 1899 October 21. *τ Tauri* 4·4 magnitude. "Reappeared first as a 9th-magnitude star, and after an interval of rather more than one second it flashed out in full brightness."

This star is without doubt a double, but, owing to the closeness and inequality of the components, it is probably now beyond the reach of any telescope.

From the apparent path of the star I determined the position of the companion $p = n.p.$ $s = 0''.15$ to $0''.4$. It is probable that no abnormal phenomena would be noticed, except for an emersion occurring between 300° and 360°, position angle.

In an unpublished list of ninety-three occultations are the following :—

1901 April 27. B.D. $+4°.2333$ 7·5 magnitude. "About one-half the light was suddenly shut off before final disappearance." The star was subsequently identified as

OΣ 218. 98·67 $p = 70°.6$ $s = 1''.15$ 7·3—9·2 mag. Hω 5″.

1901 February 25. B.D. $+20''.807$ 9· mag.

"apparently disappeared, then seen again ; the final disappearance being $3^s.8$ later."

This star was found to be

Ho 332. $p = 126°$ $s = 1''.03$ 9—9 mag.



I have on a number of occasion
stars partially buried in the limb be

The increased size of the Moon d
to retard the actual occultation of
contact with the luminous disc. B
disc, beyond the visible boundary
appears, some other explanation seem

The limb of the Moon is not a sm
elevations and depressions. When
the limb, however, appears comparat
cannot distinguish the minute irre
motion of a star occulted by the M
between o″·3 and o″·6 for one second
fore happen, taking into account th
depressions of the lunar surface, th
opening in the limb and remain vis
before disappearance.

That there are considerable elevati
Moon's limb is a well established fact.

During the total eclipse of the Su
chronograph, 9ˢ·3 before the true con
mountain, distant eight or ten degre
contact point.*

From what has already been said i
that, under certain conditions, a star
second of arc, or more, beyond the vis
before it is occulted.

According to this view the most fa
projection of a star on the disc would
was radial to the limb. For a ve
phenomenon should be less pronounced

An analysis of [illegible]

## *Saturn Visible through the Cassini Division.*

By C. T. Whitmell, M.A.

In August 1899, when engaged in studying the planet *Saturn* as a view-point, I found that there would be for *Saturn* a solar transit of the Earth on 1902 July 17. Such transits occur when (the Earth being in inferior conjunction with the Sun) *Saturn* is within about 5° 25′ of heliocentric longitude of his nodes—that is, when the heliocentric latitude, N. or S., does not exceed some 14′.

On 1902 May 24, at $5^h$ G.M.T., *Saturn* is at his descending node in longitude 292° 50′ 8″, and is in opposition to the Sun on 1902 July 17, at $13^h$ G.M.T., in longitude 294° 28′ 57″ and south latitude 0° 4′ 17″·7. The conditions for a solar transit of the Earth will therefore be satisfied on July 17.

To *Saturn* the disc of the Sun will be 192″ in diameter, that of the Earth only 2″. The chord of transit, 183″ long, lies 29″ N. of the Sun's centre, and the duration of transit of the Earth's centre for *Saturn's* centre is about $11^h\ 42^m$.

It appears also that an observer, placed in Saturnian latitude about 27° south and in a suitable longitude, will be able to view, through the Cassini division, a portion of the transit.

If we assume, with Professor Barnard, the division to be 2,270 miles broad, and the thickness of the ring-system to be 50 miles, then this division will have, at right angles to the sight line, a projected meridional breadth of about 820 miles, corresponding to about one degree of arc for the observer on *Saturn*.

At the given date, July 17, the Saturnicentric declination of the Sun is diminishing, that of the Earth increasing, and about $7^h$ G.M.T., or only $6^h$ before opposition, the Sun and the Earth are equally elevated above the ring-plane, their declination being about 22° 26′ 17″ N.

We have next to consider the matter from a terrestrial standpoint. If an observer on *Saturn* is able, through the Cassini division, to see a solar transit of the Earth, it follows that a line drawn from the Sun to the Earth can pass through this rift in the rings to the surface of *Saturn*. Thus a terrestrial observer, suitably placed, will be able to view through the rift a portion of the planet's surface lit up by sunlight, which passes through the rift, and is reflected back by the planet through the rift to the observer.

The practical effect will be that, of the arc of the Cassini division crossing the planet, a small portion will appear bright instead of dark, and may almost disappear, but probably will not quite do so, because the albedo of *Saturn* is less than that of the adjacent portions of rings A and B, which bound the fissure. Hitherto there is, I believe, no record of such a phenomenon having been observed.

actual breadth of the division as 2270 miles, and of the rings as 50 miles, I estimate, as before, the of the rift (at right angles to the line of sight, in the direction of a Saturnian meridian) as 820 een from an elevation of 22° 26′ 17″ above the

rth's distance this width corresponds to an angular ly 0″·20, so that the observation will be one of cy and difficulty.

pointed out, only when *Saturn* at opposition is in nood of a node is it possible for there to be a solar Earth, and only then can the Sun and the Earth th the planet through the Cassini division It that when *Saturn* is near a node the elevation of d Sun is considerable, so that the gap is well open of sight.

an opposition there is an appreciable difference Saturnicentric declinations of Earth and Sun, the anet, on the line of sight through the gap, will be he A ring if the Sun is lower, and by the B ring igher, than the Earth, so that the Cassini division dark where it crosses the planet, as it does where sky.

at the conditions pointed out, which rarely occur, astronomers as are favourably situated to make ove to be a unique observation. As the exact easily determinable, it seems desirable that the be watched for a few days, about 1902 July 17,

afforded by his photographs * of the region of Nova *Persei*, taken in 1901 February, March, and April, would furnish some useful evidence on the subject.

The measured photographic magnitudes of the two stars have accordingly been tabulated and plotted on square-ruled paper. In addition to these, by Dr. Rambaut's permission, some visual observations of magnitude taken at the Radcliffe Observatory are included for comparison. The visual magnitudes obtained at Poppelsdorf-Bonn by Dr. P. Guthnick, and at Bonn by Professor F. Deichmüller, are also discussed.

It will be convenient to examine the data for *κ Persei* and 36 *Persei* separately.

Dr. Guthnick's series of magnitudes of *κ Persei* from which he derives variability are the following :

TABLE I.

*Poppelsdorf-Bonn Visual Magnitudes of κ Persei.*

| G.M.T. | | Mag. | Diff. from Mean. | Compar. Stars. |
|---|---|---|---|---|
| 1901 | h | | | |
| Mar. 21 | 7½ | 3·77 | +0·27 | *ν*, *ρ*, 38, *ξ* |
| | 9 | 3·45 | +0·59 | *ν* |
| 24 | 8 | 3·98 | +0·06 | *ν* |
| 30 | 9 | 4·18 | −0·14 | *ν* |
| | 9½ | 4·13 | −0·09 | *ν* |
| Apr. 1 | 10½ | 4·12 | −0·08 | *ν*, *l* |
| 4 | 9½ | 4·23 | −0·19 | *ν* |
| | 10½ | 4·09 | −0·05 | *ν*, *σ* |
| | 11 | 4·13 | −0·09 | *ν* |
| 9 | 8 | 4·12 | −0·08 | *ν*, *ξ* |
| 18 | 8 | 4·22 | −0·18 | *ν*, *l* |
| | 8½ | 4·22 | −0·18 | *ν*, *l* |
| 22 | 8½ | 4·20 | −0·16 | *ν*, Arg. +43°, 818 |
| 23 | 9 | 4·22 | −0·18 | *ν*, *l* |
| | 9½ | 4·27 | −0·23 | *ν*, *l* |
| May 18 | 9½ | 4·0( : ) | +0·04 | *l* |
| 22 | 10 | 3·78 | +0·26 | *ν* |
| 24 | 9½ | 3·71 | +0·33 | *ν* |
| | 9½ | 3·81 | +0·23 | *ν* |

Remarking on these results, Dr. Guthnick says :

" Die Schwankungen der Helligkeit betrugen rund $0^{m}\cdot6$, die Periode scheint mindestens gleich zwei Monaten zu sein."

It should be pointed out that, of the above magnitudes, those

* Vide *Monthly Notices R.A.S.*, vol. lxii., No. 3.

March and April are entitled to much greater
ose in May, since in the latter month the constella-
is very low, and corrections required for atmo-
ion are in consequence more or less doubtful.
s point to a maximum brightness on or near
a minimum about April 23. It happens, fortu-
both of these crucial dates three observers at the
rvatory secured estimations of magnitude of the
nce to the means in Table II., which follows, will
Radcliffe observations, instead of confirming a *fall*
n the two dates, indicate either a *rise* of $0^{m}.1$, or
(when a small observational error is allowed for) a
ightness.

TABLE II.

*Radcliffe Visual Magnitudes of κ Persei.*

| Mean Mag. | Number of Observers. | Diff. from Mean. |
|---|---|---|
| 3·85 | 3 | +0·16 |
| 4·00 | 2 | +0·01 |
| 4·13 | 1 | −0·12 |
| 4·08 | 3 | −0·07 |
| 3·95 | 2 | +0·06 |
| 4·10 | 1 | −0·09 |
| 3·93 | 2 | +0·08 |
| 3·96 | 3 | +0·05 |

The results of the Radcliffe visual observations clearly suggest the necessity for further evidence before accepting Dr. Guthnick's conclusions, and such evidence is provided in the photographs.

In the next table (III.) the photographic magnitudes of the star are exhibited (column 6). The scaled values of brightness, from three independent series of measurements, determined in the manner described in the *Monthly Notices*, vol. lxii., No. 3, are given in columns 2, 3, 4. The next two columns contain the mean scaled values and their equivalents in magnitudes. The last column shows the differences from the mean, 4·70.

The stars used for comparison were *ν*, *l*, and 30 *Persei*.

TABLE III.

*Photographic Magnitudes of κ Persei.*

| G.M.T. 1901 | h | Photographic Scaled Densities. 1st Series. | 2nd Series. | 3rd Series. | Means. | Photogr. Magn. | Diff. from Mean. |
|---|---|---|---|---|---|---|---|
| Feb. 25 | 8 | 58·5 | 59·5 | 59·5 | 59·2 | 4·69 | +0·01 |
| 26 | 10 | 59·5 | 60 | 59 | 59·5 | 4·72 | −0·02 |
| 28 | 9 | 59·5 | 59·5 | 57 | 58·7 | 4·66 | +0·04 |
| Mar. 5 | 7 | 56·5 | 57·5 | 58·5 | 57·5 | 4·58 | +0·12 |
| 9 | 9 | 59 | 59·5 | 59·5 | 59·3 | 4·70 | 0·00 |
| | 9½ | 59 | 59·5 | 61 | 59·8 | 4·74 | −0·04 |
| 16 | 8 | 59·5 | 59·5 | 60 | 59·7 | 4·73 | −0·03 |
| | 9 | 57 | 59·5 | 60·5 | 59·0 | 4·68 | +0·02 |
| 21 | 9½ | 60·5 | 60·5 | 60 | 60·3 | 4·77 | −0·07 |
| | 11 | 58·5 | 57·5 | 60·5 | 58·8 | 4·67 | +0·03 |
| 22 | 8 | 60·5 | 59·5 | 60·5 | 60·2 | 4·76 | −0·06 |
| 25 | 8 | 59·5 | 58 | 57 | 58·2 | 4·62 | +0·08 |
| | 11 | 59 | 58·5 | 56·5 | 58·0 | 4·61 | +0·09 |
| 27 | 11 | 60 | 60·5 | 58 | 59·5 | 4·71 | −0·01 |
| 28 | 9 | 60 | 59·5 | 59 | 59·5 | 4·71 | −0·01 |
| 30 | 9½ | 59 | 59·5 | 55·5 | 58·0 | 4·61 | +0·09 |
| | 10½ | 60 | 60 | 57·5 | 59·2 | 4·69 | +0·01 |
| Apr. 10 | 9 | 60 | 61 | 61·5 | 60·8 | 4·81 | −0·11 |
| 13 | 9 | 58·5 | 60 | 59 | 59·2 | 4·69 | +0·01 |
| 15 | 11 | 59 | 57·5 | 60·5 | 59·0 | 4·68 | +0·02 |
| 17 | 9 | 60·5 | 61 | 61 | 60·8 | 4·81 | −0·11 |
| 19 | 9½ | 60 | 60·5 | 57·5 | 59·3 | 4·70 | 0·00 |
| 20 | 9 | 58·5 | 60·5 | 60 | 59·8 | 4·73 | −0·03 |

The mean photographic magnitude of *κ Persei* is 4·70, or 0·69 fainter than the mean visual magnitude, 4·01, the difference being probably attributable to the orange colour of the star.

nals in the last column of Table III. are too small
ne deduction of any law of sensible variation of the
ess during the period embraced in the table, viz.
o April 20.

en at the end of this paper, exhibits graphically the
Tables I., II., and III. The correction, $-0^{m}\cdot69$,
the last paragraph but one, has been applied to the
om Table III., to make the photographic and visual
rectly comparable.

seen that the photographic and Radcliffe visual
$\kappa$ *Persei* are best represented by a constant, and
case of the observations at Poppelsdorf-Bonn) by a

tudes of 36 *Persei* will be next considered.
vations at Bonn, from which Professor Deichmüller
bility, are given in the second column of Table IV.,
uthnick's and the Radcliffe magnitudes appear in
columns.

TABLE IV.

*Visual Magnitudes of* 36 *Persei.*

| Observed Magnitudes. | | | Differences from Mean. | | |
|---|---|---|---|---|---|
| Deichmüller. | Guthnick. | Radcliffe. | D. | G. | R. |
| 5·55 | 5·67 | ... | −0·25 | −0·16 | ... |
| 5·60 | ... | ... | −0·30 | ... | ... |
| 5·65 | 5·73 | ... | −0·35 | −0·22 | ... |
| ... | ... | 5·30 | ... | ... | +0·09 |

als Vergleichstern benutzt und dabei eine Veränderlichkeit desselben von ½ Grössenclasse wahrgenommen. Der Stern scheint jetzt im Maximum zu sein; die Beobachtungen könnten durch eine etwa zwei-monatliche Periode dargestellt werden." *

Dr. Guthnick, in the same number of the *Astronomische Nachrichten*, publishes his observations as confirming Professor Deichmüller's.

Both of these observers record an *increase* of $0^m.5$ in the star's light between April and May; but the Radcliffe visual magnitudes tend to show a *decrease* by May 12, when the observations were secured under very favourable atmospheric conditions, the sky being noted as "exceptionally clear." The comparison stars used on the latter date were *l Persei*, 30 *Persei*, *Arg. Z.* +43° 818, and *Arg. Z.* +44° 648.

The photographic magnitudes in Table V. are the results of three independent series of measurements, and are therefore reliable.

TABLE V.

*Photographic Magnitudes of 36 Persei.*

| G.M.T. 1901. | h | Photographic Scaled Densities. 1st Series. | 2nd Series. | 3rd Series. | Means. | Photogr. Magn. | Diff. from Mean. |
|---|---|---|---|---|---|---|---|
| Feb. 25 | 8 | 70·5 | 70·5 | 71 | 70·7 | 5·50 | +0·03 |
| 26 | 10 | 72·5 | 72 | 72 | 72·2 | 5·60 | −0·07 |
| 28 | 7 | 71 | 72 | 71 | 71·3 | 5·54 | −0·01 |
| | 9 | 69·5 | 70·5 | 71 | 70·3 | 5·47 | +0·06 |
| Mar. 5 | 7 | 71·5 | 70·5 | 71 | 71·0 | 5·52 | +0·01 |
| 9 | 9 | 70·5 | 70 | 71·5 | 70·7 | 5·50 | +0·03 |
| | 9½ | 72 | 68 | 68 | 69·3 | 5·40 | +0·13 |
| 16 | 8 | 72·5 | 74 | 71·5 | 72·7 | 5·64 | −0·11 |
| | 9 | 71 | 74 | 71·5 | 72·2 | 5·60 | −0·07 |
| 21 | 9½ | 70·5 | 73 | 72 | 71·8 | 5·58 | −0·05 |
| | 11* | 72 | 74 | 71 | 72·3 | 5·61 | −0·08 |
| 25 | 8 | 71 | 71·5 | 71·5 | 71·3 | 5·54 | −0·01 |
| | 11 | 69·5 | 71 | 71 | 70·5 | 5·48 | +0·05 |
| 26 | 9 | 71 | 70 | 71·5 | 70·8 | 5·51 | +0·02 |
| 27 | 11 | 70·5 | 71·5 | 72 | 71·3 | 5·54 | −0·01 |
| 28 | 9 | 70·5 | 71 | 70 | 70·5 | 5·49 | +0·04 |
| 30 | 9½ | 70 | 72 | 70 | 70·7 | 5·50 | +0·03 |
| | 10½ | 70·5 | 70 | 71·5 | 70·7 | 5·50 | +0·03 |
| Apr. 10 | 9 | 71·5 | 71 | 72 | 71·5 | 5·56 | −0·03 |
| 13 | 9 | 69·5 | 71 | 71 | 70·5 | 5·48 | +0·05 |
| 15 | 11 | 71·5 | 70 | 70·5 | 70·7 | 5·50 | +0·03 |
| 20 | 9 | 70·5 | 71 | 70·5 | 70·7 | 5·50 | +0·03 |

* *Ast. Nach.*, 3720.

g the means given in col. 5 of the preceding table, rd series (col. 4) should have received the greatest the results in this series depend upon a special set ns, selecting three comparison stars of suitable nd situated most favourably for the determination, ntial method, of the magnitude of the star in ques- timations in the 3rd series will be found to be in nce than those of the other two series, which are cted, though only in a slight degree, by differences ic absorption.

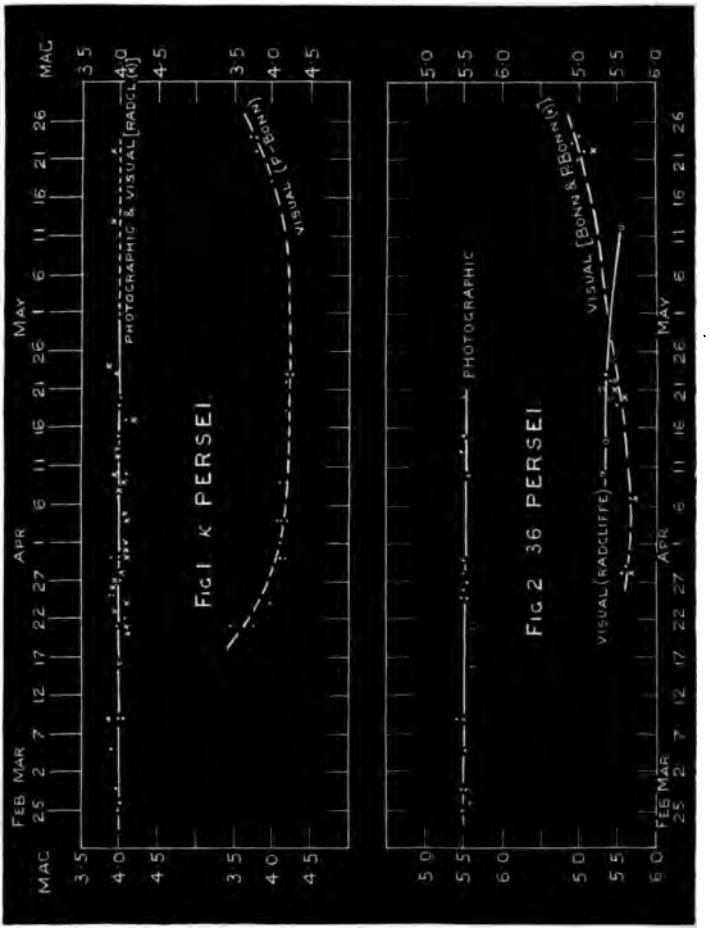
arison stars used in Series 1 and 2 were generally r, viz. / *Persei*, 30 *Persei*, *Arg.* $Z.+43°$ 818, *Arg.* *Arg.* $Z.+44°$ 734, and *Arg.* $Z.+42°$ 795; whilst es 3 were *Arg.* $Z.+45°$ 811, *Arg.* $Z.+46°$ 760, and 804.

graphic and visual magnitudes of 36 *Persei* (Tables are exhibited graphically in fig. 2.

nitudes resulting from the photographic method resented in the diagram by an almost horizontal whilst the line drawn through the Radcliffe visual s slightly curved, but in the direction opposite to ne drawn through the observations at Bonn and Bonn. A curious feature in the latter is the fact magnitude of both $\kappa$ and 36 *Persei* occurs in May aneously; but (as before pointed out) the stars in ion of *Perseus*, during the observing hours of the y, were low, and especially so in the case of the t Poppelsdorf-Bonn. Corrections for atmospheric

so bemerkenswerthe Constanz der Helligkeit gefunden, dass ein sehr viel zwingenderes Material, als bisher veröffentlicht ist, erforderlich wäre, um uns von der Veränderlichkeit der Sterne zu überzeugen."

*Radcliffe Observatory, Oxford:*
1902 *March* 25.



*able Motion of some of the Small Stars in the "Dumb-ebula* (*M* 27, *N.G.C.* 6853). By E. E. Barnard.

*hly Notices* for March 1894 (vol. liv. No. 5) Messrs. t and W. E. Wilson give a list of the photographic me of the stars in M 27, compared with the places by Otto Struve some forty-two years previously. These liscordances, in many cases amounting to as much as the different coordinates. These discordances the he above paper attribute to proper motion in these considerable motion in so many small stars seems and if real would be of the highest interest.

I measured several of these stars with the 36-inch Hamilton to verify the photographic results. These the discordances were real. A paper on the subject in *Astronomy and Astrophysics* for June 1894.

years ago I remeasured three of these stars and n additional one. I have just come across these nd have thought it well to send them to *Monthly* re they may be properly recorded. As I think there on to believe the supposed proper motions are not not thought it necessary to measure all the dis- s mentioned by Dr Rambaut.

the measures have been made in position angle and able distances being measured). For comparison with measures these have been reduced to $\Delta\alpha$ and $\Delta\delta$. In n to $\Delta\alpha$ the measures have not been multiplied by

Following are the measures with the 40-inch :—

*a* and *q*.

| | | | | |
|---|---|---|---|---|
| 1898·358 | 257°·33 | 97″·39 | | |
| ·375 | 257·25 | 97·20 | | |
| 1898·37 | 257·29 | 97·29 | − 94″·90 | −21″·42 |

*a* and *a'*.

| | | | | |
|---|---|---|---|---|
| 1898·375 | 189°·28 | 58″·32 | | |
| ·394 | 189·60 | 58·52 | | |
| 1898·38 | 189·44 | 58·42 | − 9″·58 | −57″·63 |

*a* and *d*.

| | | | | |
|---|---|---|---|---|
| 1898·358 | 83°·85 | 154″·48 | | |
| ·375 | 83·62 | 154·19 | | |
| 1898·37 | 83·73 | 154·33 | +153″·41 | +16″·85 |

*a* and *i*.

| | | | | |
|---|---|---|---|---|
| 1898·375 | 72°·24 | 247″·60 | | |
| ·394 | 72·16 | 248·36 | | |
| 1898·38 | 72·20 | 247·98 | +236″·11 | +75″·81 |

These compared with Struve's measures give the following differences, and for further comparison Wilson's measures are also given.

For the star *q*.

| | | Δα | Δδ | Δα Differences from Struve. | Δδ Differences from Struve. |
|---|---|---|---|---|---|
| | Struve | − 97″·6 | −20″·9 | | |
| | Wilson | − 94·4 | −20·6 | −3″·2 | −0″·3 |
| 1894 | Barnard | − 94·7 | −21·5 | −2·9 | +0·6 |
| 1898 | ,, | − 94·9 | −21·4 | −2·7 | +0·7 |

For the star *a'*.

| | | | | | |
|---|---|---|---|---|---|
| | Struve | − 12″·3 | −57″·2 | | |
| | Wilson | − 9·6 | −57·5 | −2″·7 | +0″·3 |
| 1894 | Barnard | − 9·6 | −57·5 | −2·7 | +0·3 |
| 1898 | ,, | − 9·6 | −57·6 | −2·7 | +0·4 |

For the star $p$.

| | $\Delta\alpha$ | $\Delta\delta$ | $\Delta\alpha$ Differences from Struve. | $\Delta\delta$ Differences from Struve. |
|---|---|---|---|---|
| Struve | + 60″·6 | + 57″·9 | | |
| Wilson | + 56·6 | + 60·1 | + 4″·0 | − 2″·2 |
| Barnard | + 57·9 | + 60·3 | + 2·7 | − 2·4 |

For the star $d$.

| | | | | |
|---|---|---|---|---|
| Struve | + 152″·5 | + 12″·8 | | |
| Wilson | + 151·5 | + 16·6 | + 1″·0 | − 3″·8 |
| Barnard | + 153·2 | + 16·1 | − 0·7 | − 3·3 |
| ,, | + 153·4 | + 16·8 | − 0·9 | − 4·0 |

For the star $i$.

| | | | | |
|---|---|---|---|---|
| Struve | + 238″·2 | + 71″·5 | | |
| Wilson | + 232·9 | + 74·3 | + 5″·3 | − 2″·8 |
| Barnard | + 236·1 | + 75·8 | + 2·1 | − 4·3 |

ures have not been reduced to the epoch of Struve's .

ferences certainly imply change of some sort if the es can be relied on. But if we examine *Phil. Trans.* rt iii., it will be seen that in the observations of ery few direct measures of distance were made, the ng computed from the observed angles along with a l distances. This is an unsatisfactory method and

These are near the nebulæ *h* 3924, *h* 3931, and *h* 3932 (N.G.C. 7213, 7232, and 7233).

New (1900) $10^h\ 56^m\ 28^s{\cdot}2$, $-64°\ 42'{\cdot}7$.

A stellar nebula found visually with the 24-inch o.g. prism. Mag. 10–11.

Immediately N.p. C.P.D. $-64°$ 1588.

Spectrum on plate 159 (12/6/1901), chart on plate 164 (14/6/1901).

New (1900) $17^h\ 49^m\ 6^s{\cdot}6$, $-21°\ 47'{\cdot}0$.

A stellar nebula found visually with the 24-inch o.g. prism. Mag. 12–13.

Immediately S.f. C.P.D. $-21°$ 6502. The nebula is $2^s{\cdot}5$ pr. a slightly brighter star of the same declination.

Photographed on plates 178 and 182 (24/6/1901 and 8/7/1901).

By Mr. R. T. A. Innes.

*h* 2518 (N.G.C. 1269). Not visible in the 7-inch. (3/12/1901.) This is perhaps the same as Δ487 (N.G.C. 1291), observed by *h* on the same night. *h* gives for the latter exactly the same declination and description as for *h* 2518.

Δ487 was well seen on the night that *h* 2518 could not be found.

*h* 3443 (N.G.C. 4815). It is doubtful if this (which *h* calls a cluster) is resolvable in the 7-inch. It is involved with, but to the S of, the two stars C.P.D. $-64°$, 2088 and 2090. Place of latter (1875), $12^h\ 50^m\ 16^s{\cdot}5$, $-64°\ 16'{\cdot}5$.

*h* 3546 (N.G.C. 5357). There is no nebula visible in the 7-inch in *h*'s position. There is a small elliptical nebula near two 10th mag. stars at (1860) $13^h\ 49^m{\cdot}8$, $-28°\ 38'$. This is 1° different from *h*'s declination.

New (1875) $13^h\ 28^m{\cdot}6$, $-61°\ 25'$.

This is a small round nebula about 1′ in diameter, brighter towards the centre.

*h* 3563 (N.G.C. 5530). As seen with the 7-inch. This is a fine nebulous star. *h* has !, vF, pmE, e s v m b M * 12.

Cordoba D.M. $-43°$, 9005. (1875) $14^h\ 14^m\ 30^s{\cdot}8$, $-43°\ 34'{\cdot}2$.

As seen with the 7-inch on 14/8/1901 this is a fine planetary nebula, 10 mag., about 20″ in diameter. Examined

ame night with the 18-inch telescope, it appeared
ll-shaped. Mr. Lunt, with the 24-inch o.g. prism,
e spectrum to be that of a gaseous nebula. This
lso appears on several *Carte du Ciel* plates. Plate
th $1^h$ exposure, shows two very elongated spindle-
nebulæ of the same length, parallel to each other,
ontact at their points of greatest condensation or
ss. Angle of elongation = 80°.
different appearances shown by the different
nts is instructive.
nebula was also found at Arequipa. See *Harvard*
, No. 60, received here 22/8/1901.

$7^h\ 34^{m}\cdot8$, $-64°\ 37'$.
int oval nebula 1′ in diameter, N. p. *η Pavonis*.
d with the 7-inch.

*rvatory, Cape of Good Hope:*
*1902 February 20.*

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*ouble Star Results*, 1901. By R. T. A. Innes.

*ted by Sir David Gill, K.C.B., F.R.S., H.M. Astronomer.*)

generally was unfavourable for double star work.

2ND METHOD.

*Transits of Polar Stars.*

| 1901. | | Dec. | Value. |
|---|---|---|---|
| Dec. 19 | $o$ Octantis | $-88^{\circ}\ 34'$ | $17''\cdot684$ |
| „ 23 | „ „ | „ „ | $17\cdot673$ |
| „ 28 | B.A.C. 1960 | 84 50 | $17\cdot655$ |

As the method of determining double star distances is akin to the 1st method described, the present series of observations has been reduced with the screw-value taken equal to

$$17''\cdot603.$$

To reduce the Cape observations of 1900 to this value they must be diminished by a $\frac{1}{215}$th part, or as follows :—

| Distances. | Correction. |
|---|---|
| $0''\cdot0$ to $1''\cdot0$ | $-0''\cdot00$ |
| $1\cdot1$ „ $3\cdot2$ | $0\cdot01$ |
| $3\cdot3$ „ $5\cdot4$ | $0\cdot02$ |
| $5\cdot5$ „ $7\cdot6$ | $0\cdot03$ |
| $7\cdot7$ „ $9\cdot8$ | $0\cdot04$ |
| 10 | $0\cdot05$ |
| 20 | $0\cdot09$ |
| 30 | $0\cdot14$ |
| 40 | $-0\cdot19$ |

The cause of the discordance between the two methods for finding the screw-value seems obscure, and will be further investigated. It is noteworthy that Otto Struve found a similar discordance at Pulkowa (*Observations*, vol. ix. pp. 18 and 24), viz.

| | |
|---|---|
| From measured distances | $9''\cdot7091.$ |
| „ transits of stars | $9''\cdot7326.$ |

He gave his preference to the former value.

The arrangement of the measures will be easily understood. The column "Diff. Mags." is only filled in when actually observed. The colours of the double stars have been frequently recorded. For brevity's sake the following contractions have been used :—

| | |
|---|---|
| Y = Yellow. | y = yellowish. |
| B = Blue. | b = bluish. |
| R = Red. | r = reddish. |

o = White.
1–3 = Different shades of yellow.
4–6 = „ „ „ orange.
7–10 = „ „ „ red.

es are followed by notes. A separate list of stars not seen double is added. Although some of the inly double it seemed best to give the list which ecord of observation. A short list of errata and the Reference Catalogue of Southern Stars is

rences to the *Cape Photographic Durchmusterung* irst column, the zone is omitted, as it may be he column S. Dec. Thus, No. 15, C.P.D. 214 is 14.]

. C. Pickering kindly sent lists of new double ound at Arequipa; some of these have since been the remainder are on the working list.

tions of *α Centauri*, by Sir David Gill and myself, rately. They show that the greatest distance than the predicted by about 0″·20.

ng casual observations may also be placed on

| | | | | | |
|---|---|---|---|---|---|
| 1901 02 | 204°·5 | ″ ... | S. S. Hough | 12 | |
| ·08 | 332·1 | 2·25 | J. Lunt | 1 | |
| ·08 | 13·2 | 3·06 | ,, | 1 | |

| R.A. 1900 h m | S. Dec. 1900 ° ′ | 1901·+ | Pos. Angle. ° | Dist. ″ | Diff. Mags. | Colours. A. | B. | No. of Nights. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| 0 1 | 49 38 | 90 | 177·4 | 5·65 | ... | ... | | 3-2 | 1 |
| 0 4 | 54 34 | 84 | 294·0 | 0·73 | ... | ... | | 1 | ... |

| Star. | Mag. | 1900 R.A. h m | 1900 S. Dec. ° ′ | 1901·+ | Pos. Angle. ° | Dist. ″ | Diff. Mags. | Colours. A. | B. | No. of Nights. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Innes 265 ... | 8·0 | 1 57 | 44 19 | 97 | 24·6 | 0·95 | 1·5 | ... | | 1 | ... |
| „ 311 ... | 8·4 | 2 2 | 82 47 | 04 | 41·5 | 1·93 | 0·7 | 2·5, B | | 3–2 | 11 |
| U.A. 13½ Horologii | 7·2 | 2 37 | 59 59 | 06 | 317·5 | 0·25 ± | 0 2 | 0, 0 | | 4 | 12 |
| λ 3541 ... | 8·5 | 2 50 | 60 20 | 41 | 156·4 | 2·52 | 1·3 | 2, b | | 2 | ... |
| C. Z. 3h 1 ... | 8 0 | 3 1 | 60 23 | 08 | 146·7 | 0·57 | 0·2 | Y, Y | | 1 | 13 |
| Cape 3 ... | 9·2 | 3 5 | 42 54 | 06 | 254·0 | 2·17 | 0·6 | ... | | 1 | ... |
| Innes 54 ... | 8·7 | 3 5 | 41 45 | 06 | 131·1 | 0 74 | 0·3 | .. | | 1 | ... |
| λ 22 ... ... | 8·0 | 3 8 | 30 39 | 06 | 343·4 | 1·17 | 2·0 | ... | | 1 | 14 |
| Innes 55 ... | 5·9 | 3 9 | 44 48 | 08 | 182·3 | 0 82 | 0·8 | 3, 3 | | 2 | 102 |
| O.A. 2179 ... | 8·5 | 3 14 | 19 26 | 08 | 163·0 | 3·86 | 1·5 | ... | | 2 | ... |
| C.P.D. 214 ... | 8·3 | 3 14 | 63 39 | 09 | 322·2 | 0·66 | 0·4 | ... | | 1 | 15 |
| Innes 150 ... | 8·2 | 3 16 | 63 26 | 09 | 358·3 | 3·80 | 3·5 | ... | | 1 | ... |
| $\chi_3$ Fornacis... | 6·6 | 3 24 | 36 12 | 95 | 251·0 | 6·54 | ... | —, r | | 1 | ... |
| C.P.D. 570 ... | 8·8 | 3 47 | 55 39 | 42 | 203·2 | 2·13 | 0·2 | ... | | 2 | 16 |
| Harvard ... | 5·6 | 3 51 | 40 39 | 06 | 172·8 | 23·1 | 6·6 | 3, — | | 2 | ... |
| Innes 269 ... | 7·3 | 3 59 | 54 41 | 40 | 78·7 | 3·38 | ... | ... | | 2 | ... |
| „ 152 ... | 7·6 | 4 1 | 35 43 | 05 | 70·5 | 0·83 | 0·0 | ... | | 1 | ... |
| „ 271 ... | 7·5 | 4 19 | 43 1 | 40 | 145·3 | 2·34 | 2·3 | 3·5, b | | 2 | ... |
| Cape 28 ... | 9·1 | 4 34 | 50 21 | 03 | 279·0 | 6·37 | 0·4 | ... | | 2 | ... |
| λ 3672 ... | 8·3 | 4 35 | 35 30 | 01 | 300·5 | 4·23 | 1·0 | —, 4 | | 1 | ... |
| α Caeli ... ... | 4·5 | 4 37 | 42 3 | 41 | 111·9 | 5·78 | 7·2 | 2, — | | 2 | ... |
| Innes 60 ... | 9·0 | 4 38 | 45 54 | 01 | 95·6 | 2·33 | 0·2 | ... | | 1 | ... |
| λ 3696 ... | 8·4 | 4 46 | 56 11 | 03 | 290 8 | 3·29 | 0·8 | ... | | 2 | 17 |
| „ AC | ... | ... | ... | 05 | 117·3 | 9 ± | 5·2 | ... | | 1 | |
| Cordoba [10] | 7·5 | 4 46 | 50 3 | 01 | 256·3 | 4·49 | 3·0 | ... | | 1 | 18 |
| θ Pictoris ... | 6·3 | 5 23 | 52 24 | 97 | 199·3 | 0·43 | 0·2 | ... | | 1 | ... |
| Lac. [1873] | 8·5 | 5 23 | 58 15 | 49 | 103·4 | 0·48 | 0·0 | Y, Y | | 2 | 19 |
| Innes 347 ... | 8·0 | 5 36 | 75 18 | 01 | 129·0 | 9·06 | 4·0 | ... | | 1 | ... |
| „ 279 ... | 8·5 | 5 43 | 43 18 | 02 | 9·4 | 0·86 | 0·7 | ... | | 1 | ... |
| „ 348 ... | 9·0 | 5 49 | 29 3 | 08 | 60 5 | 4·07 | 2·0 | ... | | 2 | 20 |
| λ 3807 ... | 8·3 | 5 49 | 41 42 | 02 | 273·1 | 5·07 | 2·0 | 4, B | | 1 | ... |
| Innes 16 ... | 7·0 | 5 49 | 38 33 | 02 | 123·1 | 1·13 | 4·0 | 4, b | | 1 | ... |
| Dualop 23 ... | 6·9 | 6 2 | 48 27 | 01 | 40·1 | 1·66 | 0·4 | ... | | 2 | ... |
| Innes 349 ... | 7·0 | 6 11 | 29 34 | 02 | 44·7 | 6 96 | ... | ... | | 1 | ... |
| „ 3 ... | 6·9 | 6 12 | 61 27 | 50 | 7·0 | 0·79 | 0·4 | Y, Y | | 2 | ... |
| Cape 23 ... | 8·5 | 6 12 | 49 5 | 01 | 63·0 | 4·42 | 1·0 | ... | | 1 | ... |
| Innes 281 ... | 8·7 | 6 18 | 44 45 | 09 | 7·3 | 6·29 | 1·8 | 2, 7 | | 2 | ... |
| Harvard ... | 6·8 | 6 20 | 45 35 | 14 | 4·0 | 34·2 | 3·0 | 4, b | | 1 | ... |

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|---|---|---|---|---|---|---|---|---|---|
| 6 22 | 50 29 | 49 | 314·4 | 1·44 | 2·2 | y, b | | 2 | ... |
| 6 23 | 48 7 | 49 | 133·3 | 1·18 | ... | y, b | | 2 | 21 |
| 6 27 | 50 10 | 02 | ... | ... | ... | ... | | 1 | 22 |
| 6 41 | 30 58 | 13 | 97 ± | 36·1 ± | 5·4 | ... | | 1 | 23 |
| 6 41 | 30 29 | 13 | 226·7 | 4·49 | 2·5 | 3, b | | 1 | ... |
| 6 42 | 64 25 | 14 | 236·0 | 5·96 | 2·5 | 2, — | | 1 | ... |
| 6 42 | 30 51 | 05 | 224·0 | 4·59 | 2·9 | 1, B | | 1 | ... |
| 6 42 | 52 19 | 01 | 342·8 | 0·78 | 0·5 | 0, 0 | | 1 | ... |
| ... | ... | 01 | 243·1 | 42·7 | 4·5 | ... | | 1 | ... |
| 6 42 | 71 40 | 14 | 332·1 | 10·8 | 3·5 | 4, - | | 1 | ... |
| 6 45 | 54 35 | 07 | 352·4 | ... | 2·5 | ... | | 1 | ... |
| 6 45 | 48 27 | 07 | 185·9 | 2·06 | 3·0 | 2, — | | 1 | 24 |
| 6 47 | 44 56 | 97 | 254·4 | 0·79 | 0·2 | ... | | 1 | ... |
| 6 47 | 28 36 | 13 | 141·4 | 0·74 | 0·5 | ... | | 1 | 25 |
| 6 47 | 45 20 | 14 | 322·5 | 6·52 | ... | 6, B | | 1 | ... |
| 6 49 | 47 38 | 14 | 121·4 | 2·48 | 0·0 | 0, 0 | | 1 | ... |
| 6 54 | 35 23 | 55 | 200·0 | [0·58] | 0·1 | 3, 3 | | 2 | 26 |
| 6 55 | 35 17 | 13 | 253·9 | 1·80 | 1·3 | 2, — | | 1 | ... |
| 6 55 | 30 52 | 13 | $9^m$ 35 ± / $10^m$ 70 ± | | ... / ... | ... / ... | | 1 | ... |
| 6 59 | 77 39 | 13 | 283·8 | 8·44 | 2·0 | 1, b | | 2 | ... |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| B Velorum ... | 4·8 | 8 19 | 48 10 | 99 | 141·0 | 0·92 | 2·5 | ... | | 1 | 32 |
| P viii. 60 ... | 6·5 | 8 19 | 26 2 | 40 | 225 ± | 12 ± | 5·0 | ... | | 1 | 33 |
| C. Z. 8h 2087 | 8·0 | 8 26 | 38 16 | 40 | 190 ± | 0·6 ± | 0·3 | ... | | 1 | 34 |
| Innes 313 ... | 7·2 | 8 27 | 41 11 | 15 | 216·7 | 3·75 | ... | 3, B | | 1 | 35 |
| ,, 355 ... | 8·2 | 8 32 | 20 43 | 99 | 39·2 | 0·75 | 0·3 | 4, 4 | | 1 | ... |
| ,, 357 ... | 8·4 | 8 58 | 23 21 | 99 | 178·8 | 0·69 | 0·4 | ... | | 1 | ... |
| Cordoba (21) | 8·3 | 9 6 | 43 46 | 61 | 47·6 | 2·78 | 0·9 | ... | | 2 | 41 |
| C.P.D. 1034 | 8·4 | 9 16 | 69 58 | 30 | 340 ± | 5 ± | 0·4 | ... | | 1 | 36 |
| Innes 12 ... | 5·4 | 9 18 | 74 28 | 09 | 267·2 | 0·38 | 0·4 | 3, 3 | | 1 | ... |
| ψ Argus ... | 3·5 | 9 27 | 40 2 | 17 | 307·2 | 0·70 | 0·5 | ... | | 2–1 | 37 |
| Innes 31 ... | 9·2 | 9 28 | 56 33 | 62 | 156·9 | 3·16 | 0·3 | ... | | 2 | ... |
| ,, 289 ... | 8·2 | 9 29 | 73 13 | 17 | 257·5 | 0·79 | 0·4 | ... | | 2 | 38 |
| ,, 200 ... | 7·7 | 9 29 | 60 48 | 17 | 358·0 | 1·20 | 2·2 | y, b | | 2 | 39 |
| ,, 201 ... | 8·2 | 9 31 | 73 18 | 17 | 152·1 | 2·07 | 2·2 | 2·5, b | | 2 | ... |
| λ 115 ... ... | 5·5 | 9 34 | 53 13 | 20 | 180 ± | 0·7 ± | 0·2 | Y, Y | | 1 | 40 |
| Innes 202 ... | 7·0 | 9 35 | 39 10 | 97 | 176·2 | 1·58 | 2·0 | 3, b | | 1 | ... |
| ,, 320 ... | 8·6 | 9 36 | 66 15 | 08 | 49·0 | 1·04 | 1·2 | 0, 0 | | 1 | 41 |
| ,, 321 ... | 9·3 | 9 37 | 58 49 | 09 | 209·8 | 2·03 | 0·0 | 0, 0 | | 1 | ... |
| C. Z. 9h 3089 | 8·5 | 9 41 | 37 6 | 97 | 340·3 | 0·72 | 0·1 | ... | | 1 | 42 |
| Hargrave 28 | 7·8 | 9 42 | 59 1 | 09 | 285·1 | 1·98 | 2·5 | 4, b | | 1 | 43 |
| Innes 172 AB | 7·7 | 9 43 | 37 16 | 97 | 311·9 | 1·04 | ... | ... | | 1 | ... |
| ,, AC | ... | ... | ... | 97 | 200 ± | 10 ± | 15m | ... | | 1 | 44 |
| ,, AD | ... | ... | ... | 97 | 270 ± | 30 ± | 13m | ... | | 1 | ... |
| Innes 204 AB | 7·2 | 9 44 | 69 39 | 08 | 124·3 | 1·53 | 2·5 | ... | | 1 | ... |
| ,, AC | ... | ... | ... | 08 | 319·5 | 3·65 | 4·0 | ... | | 1 | 45 |
| Cordoba [78] | 9·0 | 9 45 | 44 26 | 09 | 109·4 | 1·89 | 0·2 | 0, 0 | | 1 | ... |
| φ Argus ... | 3·7 | 9 53 | 54 6 | 28 | 7·4 | 37·0 | 7·8 | ... | | 1 | 46 |
| Innes 322 ... | 9·0 | 9 55 | 62 5 | 28 | 68·0 | 2·00 | 0·5 | ... | | 1 | 47 |
| ,, 290 ... | 9·2 | 9 59 | 59 36 | 09 | 272·0 | 2·68 | 1·2 | ... | | 1 | ... |
| ,, 173 ... | 5·2 | 10 2 | 46 53 | 08 | 61·2 | 0·3 ± | 2·0 | 5, 5 | | 1 | 48 |
| ,, 361 ... | 8·5 | 10 9 | 46 59 | 28 | 135·1 | 4·36 | 1·8 | 2, b | | 1 | 49 |
| ,, 207 ... | 8·5 | 10 14 | 32 43 | 28 | 323·3 | {3·49 or 2·62} | 0·2 | 1, 1 | | 1 | 50 |
| ,, 208 ... | 7·5 | 10 20 | 43 44 | 22 | 30·6 | 0·82 | 0·8 | ... | | 1 | 51 |
| ,, 33 AB | 9·3 | 10 28 | 61 3 | 09 | 41·6 | 0·65 | 0·2 | 0, 0 | | 1 | 52 |
| ,, ,, AB, C ... | | ... | ... | 09 | 116·7 | 5·07 | 0·1 | 0, 0 | | 1 | ... |
| Innes 32 ... | 9·0 | 10 28 | 61 17 | 09 | 345·1 | 5·28 | 2·0 | ... | | 1 | ... |
| C. Z. 10h 2838 | 8·7 | 10 40 | 36 21 | 20 | 350 ± | 1 ± | 0·6 | ... | | 1 | 53 |

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|---|---|---|---|---|---|---|---|---|---|
| 10 42 | 56 48 | 50 | 240 ± | 3 ± | 0·3 | ... | | 1 | 54 |
| 10 58 | 81 1 | 54 | 151·2 | 0·61 | 0·0 | 4, 4 | | 1 | 55 |
| 11 4 | 61 0 | 54 | 192·2 | 1·59 | 2·5 | 2, — | | 2 | ... |
| 11 6 | 32 1 | 53 | 127·1 | 1·01 | 2·5 | ... | | 1 | ... |
| 11 8 | 70 40 | 54 | 2·2 | 2·57 | 3·2 | 2, b | | 2 | ... |
| 11 35 | 51 8 | 53 | 35·8 | 0·86 | 0·2 | 3, 2 | | 1 | ... |
| 11 35 | 64 51 | 53 | 234·1 | 38·1 | 6·9 | 4, — | | 1 | ... |
| ... | ... | 53 | 31·7 | 42·4 | 7·4 | ... | | 1 | 55 |
| 11 36 | 49 39 | 53 | 128·1 | 1·33 | 0·0 | Y, b | | 1 | 56 |
| 11 57 | 34 6 | 53 | 236·7 | 1·13 | 0·8 | ... | | 1 | ... |
| 12 10 | 29 13 | 54 | 334·0 | 2·60 | 1·5 | 2, b | | 1 | ... |
| 12 21 | 62 33 | 67 | 118·2 | 4·63 | ... | ... | | 2 | 57 |
| 12 21 | 76 7 | 54 | 316·3 | 2·25 | 0·3 | ... | | 1 | 58 |
| 12 23 | 61 19 | 53 | 324·4 | 21·7 | 3·3 | ... | | 1 | ... |
| 12 36 | 48 25 | 73 | 355·1 | 1·40 | ... | ... | | 1 | 57 |
| 12 40 | 67 34 | 67 | 343·0 | 1·21 | 0·3 | ... | | 2 | 57 |
| 13 6 | 59 23 | 58 | 257·6 | 49·8 | 7·3 | ... | | 1 | 59 |
| 13 8 | 62 7 | 58 | 140·1 | 8·28 | 3·5 | 4·5, b | | 1 | 60 |
| 13 20 | 52 46 | 58 | 263·1 | 4·26 | 0·6 | —, r | | 1 | ... |
| 13 22 | 42 42 | 43 | 153·1 | ... | 1·7 | 4, b | | 2 | 61 |
| 13 25 | 41 57 | 43 | 230·6 | 3·68 | 2·5 | 4, B | | 2 | 62 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| Cordoba ... | 8·3 | 14 37 | 75 34 | 58 | 120·9 | 11·9 | 1·5 | ... | | 1 | 71 |
| Innes 368 ... | 9·2 | 14 38 | 62 25 | 58 | 4·0 | 3·20 | 1·2 | 2, b | | 1 | ... |
| *h* 4695 ... | 6·9 | 14 41 | 74 31 | 58 | 290·2 | 17·4 | 4·1 | ... | | 1 | ... |
| Innes 84 ... | 7·5 | 14 49 | 36 1 | 40 | 260·1 | 4·07 | 3·0 | —, 7 | | 2 | 72 |
| „ 237 ... | 8·8 | 14 53 | 41 33 | 40 | 192·6 | 0·90 | 0·5 | 5, 5 | | 2 | ... |
| „ 85 ... | 8·5 | 14 59 | 35 32 | 27 | 182·0 | 1·05 | 0·5 | 0, 0 | | 1 | ... |
| λ Lupi ... | 4·3 | 15 2 | 44 54 | 27 | 189·7 | 0·83 | 0·3 | 2, 2 | | 1 | ... |
| Innes 238 ... | 8·2 | 15 5 | 44 38 | 27 | 141·2 | 3·30 | 2·5 | 2, — | | 1 | 55 |
| Harvard ... | 7·0 | 15 9 | 43 47 | 41 | 38·6 | 13·3 | 2·5 | 2, 7 | | 2 | ... |
| Innes 86 ... | 9·5 | 15 15 | 37 54 | 27 | 262 2 | 2·10 | 1·0 | ... | | 1 | ... |
| γ Lupi ... | 3·0 | 15 28 | 40 50 | 35 | 95·0 | 0·74 | ... | ... | | 2–1 | 73 |
| C. Z. 15$^h$ 2416 | 9·3 | 15 36 | 44 24 | 66 | 197·4 | 1·20 | 0·6 | 4, 4 | | 1 | 74 |
| Innes 334 ... | 9·0 | 15 54 | 71 37 | 53 | 139·8 | 2·11 | 2·0 | —, 6 | | 1 | ... |
| Cordoba [44] | 8·3 | 16 5 | 56 9 | 56 | 131·6 | 3·17 | 2·0 | 1·5, b | | 2 | ... |
| C.P.D. 10015 | 9·1 | 16 27 | 52 27 | 60 | 120 ± | 2 ± | 0·5 | ... | | 1 | 75 |
| C. Z. 16$^h$ 2120 | 8·9 | 16 32 | 46 27 | 70 | 320 ± | 2 ± | 0·2 | ... | | 1 | 76 |
| Innes 100 ... | 6·8 | 16 48 | 73 16 | 53 | 180·1 | base | 1·5 | 3, 3 | | 1 | 77 |
| *h* 4904 ... | 7·4 | 16 57 | 75 15 | 59 | 187 0 | 7·04 | 2·0 | 2, b | | 1 | 41 |
| C. Z. 16$^h$ 4210 | 8·7 | 17 1 | 41 49 | 70 | 90 ± | 2·5 ± | 0·1 | ... | | 1 | 78 |
| Lac. 7131 ... | 7·1 | 17 1 | 41 29 | 70 | 180 ± | 0·8 ± | 0·5 | 5, 5 | | 1 | 78 |
| Mœsta 1541 | 8·7 | 17 5 | 41 52 | 70 | 30 ± | 5 ± | 2·5 | ... | | 1 | 79 |
| Lac. 7177 ... | 7·1 | 17 9 | 42 14 | 70 | 160 ± | 1·5 ± | 2·0 | ... | | 1 | 80 |
| Brisbane AB | 5·5 | 17 11 | 46 32 | 67 | 77·3 | 2·17 | ... | ... | | 3 | ... |
| C. Z. 17$^h$ 706 | 8·8 | 17 12 | 39 40 | 70 | 40 ± | 4 ± | 2·0 | ... | | 1 | 81 |
| Lac. 7211 ... | 7·5 | 17 12 | 44 7 | 64 | 11·7 | 0·51 | 0·1 | ... | | 1 | 82 |
| C. Z. 17$^h$ 802 | 8·3 | 17 14 | 42 33 | 70 | 280 ± | 2·5 ± | 1·8 | ... | | 1 | 83 |
| Innes 376 ... | 9·0 | 17 24 | 65 57 | 64 | 37·6 | 2·17 | 1·0 | ... | | 1 | ... |
| *h* 5014 ... | 5·2 | 18 0 | 43 25 | 77 | 242·3 | 1·58 | 0·1 | ... | | 1 | ... |
| Harvard ... | 6·0 | 18 0 | 73 41 | 64 | 232·1 | 2·57 | 3 0 | 2, 4 | | 2 | 84 |
| Lac. 7585 ... | 6·9 | 18 5 | 50 35 | 66 | 160·8 | 2·27 | 4·0 | ... | | 1 | 85 |
| *k* 5029 ... | 7·2 | 18 6 | 57 53 | 72 | 109·9 | 2·39 | 0·2 | 2, b | | 2 | 86 |
| *h* 5031 ... | 8·0 | 18 7 | 47 24 | 61 | 82·8 | 25·7 | 1·7 | ... | | 2 | 87 |
| Lac. 7574 ... | 6·5 | 18 7 | 68 16 | 66 | 298·3 | 2·51 | 3·5 | ... | | 1 | 85 |
| C.P.D. 5842 | 7·9 | 18 14 | 62 38 | 64 | 55·4 | 5·66 | 0·2 | ... | | 3 | 88 |
| Cordoba [51] | 7·9 | 18 16 | 42 49 | 77 | 138·9 | 3·60 | 0·3 | ... | | 1 | 89 |
| C.P.D. 8421 | 9·3 | 18 26 | 42 44 | 77 | 45·9 | 6·54 | 0·4 | ... | | 1 | 90 |
| κ Cor. Aust. | 5·7 | 18 26 | 38 48 | 71 | 358·7 | 21·8 | 0·7 | —, 2 | | 2 | ... |
| Lac. 7881 ... | 7·0 | 18 45 | 41 49 | 60 | 340·0 | 34·9 | 3·5 | 5, — | | 2 | 85 |

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|---|---|---|---|---|---|---|---|
| h m | ° ′ | | ° | ″ | | | |
| 18 47 | 61 57 | 74 | 82·9 | 0·85 | 0·1 | ... | |
| ... | ... | 82 | 93·0 | 15·3 | ... | ... | |
| 18 48 | 66 2 | 66 | 129·6 | 4·19 | 0·2 | 2, b | |
| 18 56 | 30 1 | 73 | 61·9 | 0·65 | 0·2 | ... | |
| 19 7 | 66 50 | 82 | 39·5 | 0·82 | 0·2 | ... | |
| 19 28 | 41 38 | 81 | 307·3 | 1·99 | 0·4 | ... | |
| 19 40 | 62 3 | 64 | 152·0 | 0·72 | 0·0 | 2, 2 | |
| 19 43 | 45 38 | 83 | 318·0 | 13·9 | 4·5 | ... | |
| 19 53 | 37 58 | 83 | 209·4 | 22·9 | 7·5 | ... | |
| 19 55 | 38 51 | 84 | 147·1 | 0·55 | 0·4 | 2, 2 | |
| 19 59 | 33 17 | 85 | 74·2 | 0·81 | 2·0 | ... | |
| 20 3 | 57 49 | 64 | 227·9 | 0·67 | 0·3 | 2, 2 | |
| 20 6 | 64 44 | 68 | 306·0 | 17·4 | 3·1 | 2, — | |
| 20 7 | 62 28 | 84 | 281·9 | 0·83 | 2·3 | ... | |
| 20 14 | 55 7 | 84 | 1·5 | 4·35 | 2·0 | 2, b | |
| 20 17 | 81 18 | 84 | 356·9 | 26·8 | ... | 3, b | |
| 20 30 | 45 54 | 69 | 0·8 | 1·77 | 1·0 | 2, b | |
| 20 38 | 50 51 | 85 | 219·5 | 0·90 | 0·1 | ... | |
| 20 41 | 17 4 | 85 | 299·1 | 3·91 | 0·1 | b, 3 | |
| 20 57 | 76 23 | 80 | 293·3 | 1·51 | 0·4 | ... | |
| 20 59 | 73 34 | 76 | 180? | ... | ... | ... | |
| | | 85 | 280? | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| Sellors AC | ... | ... | ... | 79 | 3·35 ± | 25 ± | 3·4 | ... | | 2 | 99 |
| Lac. 9444 | ... 6·7 | 23 14 | 34 15 | 82 | 307·0 | 43·6 | 5·3 | ... | | 1 | 100 |
| Dunlop 248 | 6·0 | 23 15 | 50 51 | 82 | 210·3 | 16·8 | ... | ... | | 1 | 101 |
| Innes 25 | ... 7·5 | 23 30 | 58 3 | 79 | 54·3 | 0·76 | 0·1 | 2, 2 | | 2 | ... |
| Lac. 9545 | ... 7·0 | 23 35 | 47 53 | 87 | 66·4 | 2·05 | 3·0 | 2, B | | 2 | 91 |
| Innes 146 | ... 7·3 | 23 50 | 37 55 | 76 | 222·6 | 0·68 | 1 4 | ... | | 1 | .. |

*Remarks.*

No.

1. Common proper motion of 0″·485. Six small stars near.
2. A 14th mag. 360° ± 20″ ±.
3. Is C.P.D. −57° No. 7. Å has 173°·6.
4. South star *decidedly* fainter and yellower. This difference of magnitude is in accordance with all the other observations, excepting those of the Southern Meridian Photometry, which makes the southern star 0·17 mag. brighter.
5. Angle has decreased about 27° in five years.
6. This fine pair was discovered at Arequipa and communicated by Professor Pickering. Bailey gives 1896·0. Possibly elongated 90°. Motion?
7. The proper motion of the chief star is 0″·181 towards 70°·6.
8. Fairly accordant angles, but elongation not sure.
9. This is a highly coloured pair. Once the comp. was called "red-brown" and once "purplish."
10. This is not the Å companion, which has only been seen by Å, and, he remarks, "must be verified." The companion measured was noted by Mr. Clymer at Arequipa in 1899, and communicated by Professor Pickering.
11. The p. m., if any, is very small.
12. Found with the 18-inch telescope = Innes 386. This is the following of two nearly equal mag. stars, the pr. being 7·0 mag., colour yellow 3. The close pair is white. As a wide pair this is certainly Å 3525, with an error of 1° in Å's declination. Å 3525 was not found at the Sydney Observatory in 1879. Å 1836·8, 274°·3. 35″·1, 0·0, 1n.
13. Found with the 18-inch telescope = Innes 387.
14. Wrongly identified by the λ observers. It is O.A. 2112.
15. Found with the 18-inch telescope = Innes 388.
16. " " " " 389.
17. The faint companion was added with the 18-inch, with which it is very difficult. The Å pair is in certain motion, 24° in 67 years—probably due to pr. motion in one of the components.
18. The chief star has been measured as λ 40, dist. = 0″·43—now certainly single.
19. Found with the 18-inch telescope = Innes 390.
20. Two 12th mag. stars, 3″ apart, are 1′ N.
21. P.m. = 0″·03 towards 270°.
22. In the reference catalogue of southern double stars the measures of this star as a triple are given. Bailey (*Harvard Annals*, xxxii. pp. 300, 308) remarks that it is a quadruple. It was observed here on one night, C−D 105°·1, 0″·3 ±, d.m. 0·1, elongation perhaps doubtful, star bluish. At the same time it was noted that in A−B the smaller star (0·1 mag.) is *following*, both stars yellow.
23. From the Harvard list. Angle and distance only roughly taken; still the latter is certainly nearly correct. Bailey has 15″ ±.

ber motion is insensible.
int stars about 60″ N. ±.
lances are certainly too great, stars only slightly elongated.
pair was found with the 7-inch in 1896. The measures and
ates are:

| | | | |
|---|---|---|---|
| 1896·9 | 150° ± | 0″·6 ± | Innes. |
| 1897·3 | 160 ± | ... | " |
| 1898·3 | 190·3 | 0·26 | See. |
| 1900·5 | 188·7 | 0·25 ± | Innes. |
| 1901·5 | 200·0 | 0·4 ? | " |

ncrease in angle is about 10° per annum.
f star of a little cluster. C.P.D. mag. = 8·4, B.D. = 9·0. New?
es 391.
ith the 18-inch telescope = Innes 392.
y fixed. Several very faint stars near.
a 12th mag. pair 2′ N. pr.

notion = 0″·02 towards 270°. The measures agree with the
tes made four years ago.
ith the 7-inch telescope = Innes 393. The p.m. is insensible.
Hough 526.
ith the 7-inch telescope = Innes 394. This star is the N.f., and
est of a group of three stars.
ag. star is 30″ ± pr.
pe 33. Found by Mr. R. T. Pett at the transit circle.
ncrease of angle = 15° per ann. The period will be about
rs. Is difficult to measure, distance diminishing.
ag. star, 38″, 6°.
ag. star, 30″ N. pr.
d with the 7-inch.
int stars near.

No.

60. Found with the 7-inch = Innes 399. There is an $11^m$ star 60″ due S.
61. Found with the 7-inch = Innes 400. The distances, viz. 4″·60 and 5″·56, are discordant; a 3rd observation must be taken to see which is correct. There is a 14th mag. star 15″ pr. C.Z. $13^h$ 1221, mag. 9·1 is closely N. pr.
62. A 15th mag. star is at 12″ ± 83° ±, and there are two brighter stars 20″–30″ distant, one N., one S.
63. Found with the 18-inch = Innes 401. C.Z. $13^h$ 2915 mag. 9·1 is closely N.f., and with C.Z. $13^h$ 2913 forms *h* 4625.
64. Many faint stars about, a 15th mag. 46″ ± 317° ±.
65. Considerable change shown. Common p.m. of 0″·134 towards 338″·7.
66. New, 15th mag. too faint to measure.
67. New, found with the 18-inch = Innes 402. The p.m. is under 0″·01.
68. This very difficult companion was measured whilst making an attempt (unsuccessful) to see the three comites to the chief star found at Arequipa by Professor W. H. Pickering. The p.m. of the chief star is 0″·06 towards 180°.
69. Too faint to measure.
70. The p.m. of the chief star is 0″·044 to 229°·1.
71. A 13th mag. star completes a neat triangle. The distance derived from the Cordoba meridian observations seems to be too small.
72. An 11th mag. star 20″ ± N.f.
73. The distance is probably too great. There is no certain change in this pair since 1897.
74. Found at the 7-inch = Innes 403. Mag. taken from Cordoba D.M. C.Z. has $8{\cdot}0^m$, which is more likely.
75. Found with the 7-inch = Innes 404.
76. ,, ,, ,, 405. There is an unrecorded $9^m{\cdot}5$ star 2′ N., not in any D.M.
77. The p.m. is under 0″·04.
78. Both found with the 7-inch = Innes 406 and 407.
79. Found on a *Carte du Ciel* plate by Mr. R. Woodgate, = Cape 34.
80. Found with the 7-inch = Innes 408.
81. ,, ,, = ,, 409. The N. star of a triangle.
82. Found at Arequipa and communicated by Professor Pickering. Mr. Clymer gives 1899, 350° ± 0″·6 ±. A fine pair.
83. Found with the 7-inch = Innes 410. C.Z. $17^h$ No. 808, mag. 8·6, is 5 secs. following.
84. This fine pair has a common proper motion of ″·231 towards 195″·3.
85. Found by Professor Bailey and communicated by Professor Pickering.
86. Faint star near.
87. On the occasion of the 2nd measure the chief star was suspected to have a close companion S. pr.
88. Found by Mr. R. T. Pett at the Transit Circle = Cape 35. Colours slightly contrasted. In a triangle of faint stars, with many very faint stars interspersed.
89. Two faint stars N. and S.
90. Found on a photo-plate by Mr. Woodgate = Cape 36. There is a $12^m$ star 90° ±, 15″ ± (18-inch).
91. Found at Arequipa by Mr. Clymer and communicated by Professor E. C. Pickering.
92. A $12^m$, 83° ± also seen.
93. Found with the 18-inch = Innes 411.
94. Elongations very doubtful; this pair must be in very rapid motion.
95. Communicated by Professor Pickering. Mr. Clymer at Arequipa gives 1899, 105° ± 0″·5 ±. My settings were quite independent, but at no time was the elongation over-certain.

Proper motion in $\alpha$: no material.
,, ,, $\delta = -0''{\cdot}08$.

y Mr. R. T. Pett at the transit circle = Cape 37.
easures were very hard to get—little better than estimates.
at Arequipa by Mr. Clymer. The p.m. of the chief star is
towards 222°·2.
with the 18-inch.
istances, clouds, difficult. Found at Arequipa by Mr. Clymer.
proper motion of 0″·044 towards 154°·7.
le system—although showing no great change—has a common
r motion of 0″·08 towards 112°·0.

## *α Centauri.*

easures were taken with the Repsold micrometer on
refractor.

| os. Ang. | Distance. | Observer. | Number. | Telescope. |
|---|---|---|---|---|
| 210°5 | 21″·74 | Gill | 5–4 days | E. |
| 210·7 | ·74 | Innes | 11 „ | W. |
| 210·6 | ·76 | „ | 4 nights | W. and E. |
| 210·7 | ·76 | „ | 6 „ | „ |
| 210·7 | ·67 | „ | 6 days | „ |

asure consists of four settings for position angle and
le distances for distance.
ns for the previous year (reduced to the same value
neter screw = 17″·603) are :

greater number of the stars will be further examined. This list completes the record of observation.

| Star. | Mag. | R.A. 1900. h m | S. Dec. ° ′ | Date of Observ. 1901·+. | Remarks. |
|---|---|---|---|---|---|
| $\kappa$ Phœnicis ... | 3·9 | 0 21 | 44 14 | 82 | Not seen double. See has 13th mag. 8″ 1n. |
| $\alpha$ „ | 2·4 | 0 21 | 42 51 | 82 and 94 | Is $\lambda$ 6, 13th mag. 9″·7 6n. Not seen double. On the second occasion the bright star was kept outside the field. |
| $\lambda$ 30 ... | 6·7 | 3 42 | 54 35 | 01 | Certainly single. This is the chief star of $h$ 3592, which has a com. p.m. of 0″·065 towards 23°·5. |
| $\alpha$ Columbæ ... | 2·7 | 5 36 | 34 8 | 02 | Not seen, good. |
| Innes 162 ... | 7·5 | 7 53 | 52 38 | 99 | Single. |
| „ 169 ... | 7·2 | 9 7 | 42 52 | 09 | Single. |
| „ 203 ... | 8·2 | 9 36 | 62 6 | 09 | Single. (Found 1897 May 21, and confirmed 1897 May 28.) |
| Lac. 4096 ... | 8·0 | 9 51 | 70 59 | | This was found to be double at the 7-inch 1901·4, 260° ±, 1″ ± companion = 11m, but on 1901·97 the small star could not be seen with the 18-inch. |
| Innes 176 ... | 9·6 | 11 1 | 46 53 | 53 | No companion seen. |
| $\lambda$ 145 ... | 6·4 | 12 5 | 37 19 | 54 | Round, under $\frac{1}{2}$″ if double. |
| Innes 309 ... | 7·7 | 12 26 | 77 38 | 54 | Not seen. (Seen *twice* in 1898.) |
| „ 219 ... | 8·5 | 12 26 | 55 34 | 54 | Not seen. |
| Harvard ... | 6·2 | 14 38 | 55 11 | 58 | The nearest *comes* seen to this star is due f. = 90°, and is much nearer Bris. 5026 than Lac. 6057. Bris. 5026, colour 6. |
| Innes 226 ... | 7·0 | 14 48 | 33 44 | 27 | Not seen; hazy. |
| Lac. 6847 ... | 6·8 | 16 29 | 72 6 | 59 | Not seen, but definition not good. This is a very difficult pair found by Professor Bailey and communicated by Professor E. C. Pickering. |
| $\lambda$ 321 ... | 7·0 | 17 8 | 39 39 | 74 | Single. |
| $\lambda$ 330 ... | 8·7 | 17 24 | 30 11 | 70 | Single; a faint comes is 30″ pr. Professor See's measure may be transferred to the double star 1m 23° f. and 2′·2 S. = OA 16867. |
| Lac. 7561 ... | 6·9 | 18 5 | 63 43 | 66 | No companion seen. Professor Bailey has 13m·2, 19″ ±. Chief star, colour orange = 5. |
| $\delta_1$ Telescopii | 5·1 | 18 24 | 45 59 | 66 | Not seen double, fair definition. Professor Bailey has 1894·7, elongated. |
| $\lambda$ 359 ... | 7·7 | 18 40 | 43 53 | 81 | Probably single. |

| Mag. | R.A. 1900. h m | S. Dec. ° ′ | Date of Observ. 1901+. | Remarks. |
|---|---|---|---|---|
| | | | 82 | Single; good definition. Neighbouring stars also single. |
| 9·0 | 19 19 | 42 5 | 80 | Single; several neighbouring stars also examined. |
| 6·7 | 19 33 | 42 30 | 80 | Single. |
| 7·2 | 19 57 | 36 20 | 84 | Neither *comes* seen. |
| 7·7 | 20 9 | 63 28 | 84 | Certainly single. This star has been struck out of the list of double stars. |
| 9·0 | 20 27 | 44 51 | 85 | Single. Seen *twice* in 1896 and measured once in 1900. |
| 9·0 | 21 15 | 52 12 | 76 | Not found; good search. This star has now been struck out of the list. |
| 8·9 | 23 36 | 34 45 | 82 | Not seen double. |
| 8·1 | 23 55 | 40 45 | 79 | Not seen double (two nights). |

*ata, &c., in the Reference Catalogue of Double Stars.*

2. This star and several others observed by *h* in the same ep require a correction of $+1^s$ in R.A. *h* 3362 is thus the e star as *h* 2043 = Ref. Cat. $1^s$ No. 24.
is also P. iv. 230. Although a wide pair (14″) there is a mon proper motion of 0″·11 towards 328°·0.
hief star is V Puppis.
s C. Z. $8^h$ 758, mag. 8·6. $\alpha = 8^h\ 10^m\ 15^s\ \delta = -37°\ 22'·5$.
s C. Z. $8^h$ 2233, mag. 7·8. $\alpha = 8^h\ 27^m\ 37^s\ \delta = -36°\ 21'·2$.

## *Results of Double Star Measures with the 8-inch Equatorial at Windsor, New South Wales, in* 1901.

By John Tebbutt.

| Ref. No. | Star. | Observed Mags. | Approx. Place of Star 1901·0. R.A. h m | Dec. S. ° ′ | Fraction of Year. | Position Angle. ° | Distance. ″ | No. of Obs. | Mag. Power. | Eyes. | Hour-Angles. h m | h m | Weight 1 to 5. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | β Phœnicis | 5, 5 | 1 1·7 | 47 15 | ·975 | 18·8 | 1·41 | 10–6 | 300 | P | 3 6 W | 3 29 W | 3 |
| 2 | „ | 5, 5 | „ | „ | ·980 | 18·1 | 1·51 | 10–7 | 300 | P | 2 49 W | 3 13 W | |
| 3 | κ Toucani | 5, 8 | 1 12·4 | 69 24 | ·980 | 350·9 | 5·66 | 10–10 | 300 | P | 3 20 W | 3 51 W | |
| 4 | „ | 5, 8 | „ | „ | ·983 | 354·0 | … | 10 | 300 | R | | | |
| 5 | „ | … | „ | „ | ·983 | 354·2 | … | 10 | 140 | R | 1 34 W | 2 32 W | 2 |
| | „ | … | „ | „ | ·983 | 352·0 | … | 10 | 300 | P | | | |
| 7 | Lac. 1889 | 6, 6¼ | 5 28·1 | 42 22 | ·309 | 168·7 | 7·66 | 10–6 | 300 | P | 3 25 W | 3 49 W | 3 |
| 8 | Å 3784 | 6, 8½ | 5 35·4 | 46 9 | ·282 | 59·3 | 5·66 | 10–4 | 140 | P | 3 38 W | … | 3 |
| 9 | Å 3789 | 8, 8½ | 5 36·6 | 50 11 | ·309 | 359·5 | 9·25 | 10–6 | 140 | P | 3 55 W | 4 17 W | 3 |
| 10 | Å 3823 | 8½, 8½ | 5 56·7 | 31 3 | ·263 | 113·8 | 2·85 | 10–6 | 300 | R | 3 44 W | 4 23 W | 3 |
| 11 | „ | 8½, 8½ | „ | „ | ·266 | 110·6 | 2·92 | 10–6 | 140 | R | 1 48 W | 2 20 W | 3 |
| 12 | Å 3834 | 6, 9 | 6 1·8 | 45 5 | ·263 | 227·9 | 3·77 | 10–7 | 300 | PR | 2 53 W | 3 23 W | 4 |
| 13 | „ | 5, 9 | „ | „ | ·277 | 230·1 | 3·73 | 10–5 | {300 / 140} | P | 3 43 W | 4 12 W | 3 |
| 14 | Lac. 2145 | 6, 6½ | 6 2·2 | 48 27 | ·260 | 37·7 | 1·89 | 10–7 | 300 | P | 4 24 W | 4 51 W | 4 |
| 15 | „ | … | „ | „ | ·263 | 42·4 | 1·77 | 10–7 | 300 | R | 2 8 W | 2 43 W | 5 |
| 16 | „ | … | „ | „ | ·266 | 42·0 | … | 9 | 300 | R | 2 27 W | … | 3 |

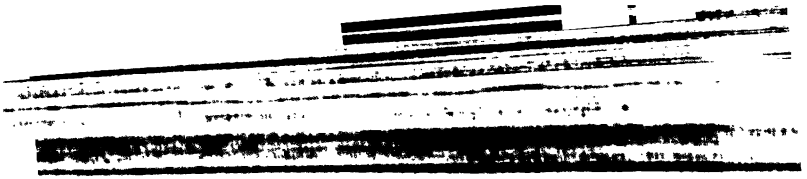




| served lags. | Approx. Place of Star 1901·0 R.A. h m | Dec. δ. ° ′ | Fraction of Year. | Position Angle. ° | Distance. ″ | No. of Obs. | Mag. power. | Eyes. |
|---|---|---|---|---|---|---|---|---|
| ... | 6 2·2 | 48 27 | ·277 | 39·1 | 2·04 | 10–7 | 300 | P |
| 8, 9 | 6 11·6 | 61 27 | ·279 | 185·3 | 1·41 | 10–5 | 300 | P |
| 7, 8 | 6 11·9 | 65 30 | ·279 | 116·9 | 21·13 | 10–7 | 140 | P |
| 5, 8 | 6 36·0 | 48 8 | ·279 | 320·3 | 13·63 | 10–6 | 300 | R |
| , 8 | 6 41·7 | 30 51 | ·309 | 224·7 | 4·87 | 10–7 | {535 140} | P |
| , 8 | 7 9·6 | 70 20 | ·288 | 299·1 | 13·54 | 10–6 | 140 | P |
| 7 | 7 18·0 | 52 8 | ·288 | 21·5 | | | | |

| Ref. No. | Star. | Observed Mags. | Approx. Place of Star 1901·0. R.A. h m | Dec. S. ° ′ | Fraction of Year. | Position Angle. ° | Distance. ″ | No. of Obs. | Mag. power. | Eyes. | Hour-Angles. h m | h m | Weight 1 to 5. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 36 | N. Hydræ | 4½, 4½ | 11 27·4 | 28 43 | ·255 | 211·3 | 9·35 | 10–7 | 300 | R | 2 22 E | 1 58 E | 4 |
| 37 | ,, | 5, 5 | ,, | ,, | ·257 | 212·2 | 9·05 | 10–6 | 300 | R | 2 26 E | 1 58 E | 3 |
| 38 | *h* 4455 | 5, 7½ | 11 31·7 | 33 1 | ·255 | 244·8 | 3·82 | 10–5 | 300 | R | 1 50 E | 1 26 E | 3 |
| 39 | ,, | 5, 7 | ,, | ,, | ·257 | 245·4 | 3·75 | 10–6 | 300 | R | 3 42 E | 3 17 E | 4 |
| 40 | β Hydræ | 5, 5½ | 11 47·9 | 33 21 | ·255 | 353·0 | 1·77 | 10–7 | 300 | P | 3 17 E | 2 55 E | 4 |
| 41 | ,, | 5, 5½ | ,, | ,, | ·257 | 350·5 | 1·60 | 10–7 | 300 | P | 3 23 E | 2 53 E | 4 |
| 42 | ,, | ... | ,, | ,, | ·260 | 351·0 | 1·73 | 10–7 | 300 | P | 3 41 E | 3 17 E | 4 |
| 43 | ε Chamæl. | 5, 7 | 11 54·7 | 77 40 | ·255 | 187·0 | 1·59 | 10–7 | 300 | P | 4 11 E | 3 39 E | 2 |
| 44 | ,, | 6, 6½ | ,, | ,, | ·260 | 186·8 | 1·57 | 10–7 | 300 | P | 2 26 E | 1 59 E | 5 |
| 45 | β Muscæ | ... | 12 40·2 | 67 34 | ·222 | 343·1 | 1·57 | 10–6 | 300 | R | 2 11 E | 1 37 E | 3 |
| 46 | ,, | ... | ,, | ,, | ·225 | 342·9 | ... | 10 | 300 | P | 3 43 E | ... | 4 |
| 47 | ,, | ... | ,, | ,, | ·236 | 347·1 | ... | 10 | 300 | P | 4 44 E | 4 3 E | 2 |
| 48 | ,, | ... | ,, | ,, | ·236 | 344·4 | ... | 10 | 300 | P | | | 3 |
| 49 | ,, | 5, 5 | 12 40·2 | 67 34 | ·241 | 341·7 | 1·42 | 10–6 | 535 | P | 3 57 E | 3 28 E | 4 |
| 50 | *h* 4634 | ... | 13 50·7 | 55 33 | ·222 | 26·6 | 14·55 | 10–6 | 140 | P | 4 8 E | 3 38 E | 3 |
| 51 | ,, | ... | ,, | ,, | ·241 | 26·2 | ... | 6 | 300 | P | 4 18 E | 3 40 E | 4 |
| 52 | ,, | ... | ,, | ,, | ·241 | 27·0 | 14·31 | 10–6 | 140 | P | | | |
| 53 | α Centauri | ... | 14 32·9 | 60 25 | ·975 | 210·3 | 21·60 | 10–10 | 140 | R | 1 7 W | 1 40 W | 2 |
| 54 | θ Gruis | 5, 8 | 23 1·3 | 44 3 | ·975 | 27·3 | 1·46 | 10–5 | 300 | P | 4 11 W | 4 35 W | 3 |
| 55 | ,, | 5, 8 | ,, | ,, | ·980 | 30·0 | 1·62 | 10–5 | 300 | P | 4 13 W | 4 37 W | 3 |





*Remarks.*

ıe components were noted as equal. 13, principal component orange, companion blue. but according to Innes' Reference Catalogue, Sellors made the south component the brigh ıions blue. Innes' Catalogue gives both components of 31 as yellow, and it would appe been assigned to the companion of 38. 22, both components orange. In 1883 and Fe y me to be blue. 25, observations very difficult: the distance is estimated. 26, I h and thought it might possibly be a thickening of the diffraction ring at the spot. The co en. 27, Herschel and Pollock's companion not seen. 36, the north following com orange, companion blue. 40, 41, 42, the south component slightly the bright companion blue. 54, 55, companion pale blue.

## *The Parallax and Proper Motion of Nova Persei, from Photographs taken at the Royal Observatory, Greenwich.*

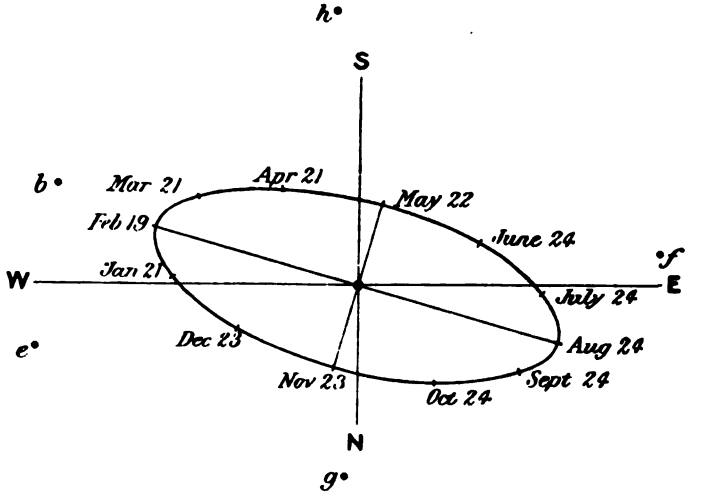
(*Communicated by the Astronomer Royal.*)

Photographs of Nova *Persei* have been taken with the Astrographic Equatorial at intervals from 1901 February 28, the earliest date on which it could be observed at Greenwich, to the present time. Twenty of these photographs have been measured for the determination of parallax and proper motion in R.A. and six for the proper motion in declination. The distances of the Nova from the three stars *e*, *b*, *f* were measured for the displacement in R.A., and *g* and *h* for that in Dec.

The positions and magnitudes of these reference stars are :—

| Mag. | No. in B.D. | R.A. 1900. | Dec. 1900. | Distance and Pos. Angle from Nova. |
|---|---|---|---|---|
| | ° | h m s | ° ′ ″ | ′ ° |
| *e* 9·1 | 43, 731 | 3 21 34·92 | 43 38 39·2 | 31 280 |
| *b* 7·7 | 43, 732 | 3 21 46·67 | 43 24 21·3 | 30 252 |
| *f* 9·2 | 43, 757 | 3 27 3·65 | 43 30 45·2 | 29 96 |
| *g* 8·8 | 43, 740 | 3 24 17·62 | 43 51 57·9 | 18 356 |
| *h* 9·2 | 42, 773 | 3 24 10·66 | 43 7 24·2 | 26 186 |

The right ascensions and declination for 1900·0 are taken from Mr. Bellamy's paper in the *Monthly Notices*, vol. lxi. March.




The positions of these stars relatively to the Nova are shown on the diagram, and for convenience the form and position of the parallactic ellipse are given, but necessarily on a greatly magnified scale.

surement was made by comparison with a glass scale
illimetres: two microscopes are carried on the same
f these is set on a division of the scale by a screw
slide, and the image of the star is bisected by the
of the second microscope. The screw of this micro-
hree revolutions to the millimetre. For bisecting
ge parallel wires are used, which can be set at any
rt. For the early photographs where the image of
as very large the wires were set at 0·50 rev. (= 10″)
he later photographs 0·20 rev. (= 4″). In making
s the following precautions were taken:
1 distance was measured in a direct and reversed
he plate.
same divisions of the scale were used for all the
.
ch image was bisected twice, the right-hand micro-
set on consecutive divisions of the scale. Each pair
thus furnishes a determination of the runs of the
.
same parts of the screw were used on all the
.
photographs were measured in duplicate by Mr.
Mr. Davidson.
owing table gives the measured distances (corrected
on and aberration) *ne*, *nb*, *nf*, *ng*, *nh*, and *ef*, the
being measured to test the constancy of the scale and
n the results.

| Date. | Z.D. | *ne.* 1862″·57. | *nb.* 1803″·68. | *nf.* 1742″·61. | *ng.* 1098″·14. | *nh.* 1585″·44. | *ef.* 3603″·32. |
|---|---|---|---|---|---|---|---|
| 1901. | ° ′ | ″ | ″ | ″ | ″ | ″ | ″ |
| Jan. 24 | 29 3 | +·21 | +·13 | −·16 | | | ·00 |
| Feb. 9 | 21 45 | +·09 | −·04 | −·03 | +·10 | −·11 | −·06 |
| 9 | 24 0 | ·00 | +·02 | +·03 | +·19 | ·00 | ·00 |
| 12 | 26 29 | −·62 | −·43 | −·15 | +·06 | −·08 | −·49 |

In the above table it should be noticed that *ne* and *nb* are on the same side of the Nova, in position angles only 28° apart, while *nf* is on the opposite side, so that if the Nova has any motion in right ascension *nf* should increase as *ne* and *nb* decrease. Similarly *ng* and *nh* are in nearly opposite directions north and south. The changes of scale indicated by the measures of *ef* are small, and in some cases the figures only represent the accidental error of measurement. The two days, September 21 and February 12, seem abnormal, and the photographs are on this account open to some suspicion. They have been carefully examined, and nothing has been found wrong in the measurement or in the photographs themselves.

In forming the following table the scale of each photograph has been corrected so as to make *ef* equal to its mean value, 3603″·32. The right ascension is determined from the three stars *e*, *b*, *f*, and the declination from *ng* and *nh*.

The right ascension deduced from the three stars *e*, *b*, *f* and the declination from the two stars *g* and *h* are :

| R.A. 1900·0. | Epoch. | Declination 1900·0. | Epoch. |
|---|---|---|---|
| $3^h\ 24^m\ 24^s·199$ | 1901·58 | 43° 33′ 42″·41 | 1901·64 |

The following table gives the separate determinations of R.A. and Dec. of the Nova :

| Date. | Seconds of R.A. From *ne.* 24ˢ·203. | From *nb.* 24ˢ·164. | From *nf.* 24ˢ·230. | Mean. 24ˢ·199. | Seconds of Dec. From *ng.* 42″·08. | From *nh.* 42″·88. | Mean. 42″·41. | Pos. of Instrument with respect to Pier. |
|---|---|---|---|---|---|---|---|---|
| 1901. | s | s | s | s | ″ | ″ | ″ | |
| Feb. 28 | +·021 | +·017 | +·014 | +·017 | +·24 | +·06 | +·15 | E. |
| Mar. 3 | +·032 | +·006 | +·019 | +·018 | +·24 | +·04 | +·14 | E. |
| Mar. 12 | −·003 | −·015 | −·002 | −·007 | −·09 | ·00 | −·04 | E. |
| Apr. 18 | ·025 | −·018 | −·011 | −·018 | ... | ... | ... | E. |
| Apr. 21 | +·023 | +·029 | +·037 | +·030 | ... | ... | ... | E. |
| Apr. 23 | +·004 | +·038 | −·010 | +·011 | ... | ... | ... | E. |
| Apr. 25 | +·016 | +·029 | +·013 | +·019 | ... | ... | ... | E. |
| Apr. 27 | +·021 | +·011 | +·023 | +·018 | ... | ... | ... | E. |
| Apr. 30 | −·004 | +·011 | ·000 | +·002 | ... | ... | ... | E. |
| May 8 | +·008 | −·002 | +·011 | +·006 | ... | ... | ... | E. |
| Aug. 10 | −·040 | −·030 | −·038 | (−·036) | ... | ... | ... | W. |
| Aug. 23 | −·012 | −·007 | −·017 | −·012 | ... | ... | ... | W. |

## *Erratum.*

| Seconds of R.A. | | | | Seconds of Dec. | | |
|---|---|---|---|---|---|---|
| From 40. 24ˢ·203. | From 08h. 24ˢ·164. | From 07. 24ˢ·230. | Mean. 24ˢ·199. | From 09. 42″·00. | From 08h. 42″·82. | Mean 42″·41. |
| s | s | s | s | " | " | " |
| −·018 | −·027 | −·010 | −·019 | ... | ... | ... |
| −·008 | −·011 | −·026 | −·015* | ... | ... | ... |
| ·009 | −·016 | −·009 | −·013 | ... | ... | ... |
| −·005 | −·009 | +·005 | −·003 | ... | ... | ... |
| −·019 | +·011 | +·014 | +·015 | ... | ... | ... |
| −·011 | −·001 | −·000 | +·003 | −·12 | −·08 | −·10 |
| ·000 | +·002 | −·003 | ·000 | −·19 | ·00 | −·09 |
| −·034 | −·017 | −·008 | −·020* | −·22 | −·15 | −·04 |

(1ˢ in R.A. = 10″·85 in arc of a great circle.)

sures made on August 10 are bracketed, as
amination of the images that the dome had cut
n of the object-glass on one side. Half
ven to the measures marked * on account
scale-value which these photographs show.
he ten plates from February 28 to May 8 an
02 January 6 to February 12 we obtain −ˢ·0
motion in R.A. Similarly the proper moti
= −0″·20. Owing to the difficulties arising
he image of the Nova in the early photographs,
only provisional, but they show that the Nov
arge proper motion.

# MONTHLY NOTICES

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Henry Tresawna Gerrans, M.A., Worcester College, Oxford; and
Maurice Edmond Gheury, 23 Downshire Hill, Hampstead, N.W.,

were balloted for and duly elected Fellows of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Henry Cunliffe Hardman, Ruskin College, Oxford (proposed by Sir R. S. Ball);
Francis Kennedy McClean, 1 Onslow Gardens, South Kensington, S.W. (proposed by Frank McClean); and
Rev. Edwin Albert Phillips, B.A., Lecturer in Mathematics, the Training College, Exeter (proposed by Arthur W. Clayden)

Seventy-two presents were announced as having been received since the last meeting, including amongst others:—

Sir N. Lockyer, Total Eclipse of the Sun, May 28, 1900: Account of Observations, presented by the Solar Physics Committee; 63 Charts of the Photographic Chart of the Heavens, presented by the French Ministry of Public Instruction.

## *me (q) in Astronomical Formulæ with Numerical Tables.* By R. T. A. Innes.

me $q$, introduced by Jacobi, can be used in several l formulæ, chiefly as a convenient means of calculating f the complete elliptic integrals. It is defined by the uations :—

$$q = \epsilon^{-\pi\frac{K_1}{K}}$$

$$\int_0^{\frac{\pi}{2}} \frac{d\chi}{\sqrt{1-k^2\sin^2\chi}}; \qquad K_1 = \frac{2}{\pi}\int_0^{\frac{\pi}{2}} \frac{d\chi}{\sqrt{1-k_1^2\sin^2\chi}}$$

$$k^2 + k_1^2 = 1.$$

$$1 + \left(\tfrac{1}{2}\right)^2 k^2 + \left(\frac{1\cdot 3}{2\cdot 4}\right)^2 k^4 + \left(\frac{1\cdot 3\cdot 5}{2\cdot 4\cdot 6}\right)^2 k^6 + \&c.$$
$$= [1 + 2q + 2q^4 + 2q^9 + 2q^{16} + \&c.]^2$$

ese formulæ we may derive

$$k^2 + \tfrac{1}{32}k^4 + \tfrac{21}{1024}k^6 + \tfrac{31}{2048}k^8 + \&c. \quad \ldots \quad \ldots \quad (a)$$

$$\sqrt{k} + 2(\tfrac{1}{2}\sqrt{k})^5 + 15(\tfrac{1}{2}\sqrt{k})^9 + 150(\tfrac{1}{2}\sqrt{k})^{13} + \&c. \quad \ldots \quad (b)$$

evident that if $q$ is tabulated as a function of $\theta$, it will not be necessary to extend the table beyond 45°.

Let $q_1$ stand to $k_1$ as $q$ does to $k$, then

$$q = \epsilon^{-\pi \frac{K_1}{K}} \qquad \text{and} \qquad q_1 = \epsilon^{-\pi \frac{K}{K_1}}$$

and

$$\log \frac{1}{q} = \pi \frac{K_1}{K} \log \epsilon\,; \qquad \log \frac{1}{q_1} = \pi \frac{K}{K_1} \log \epsilon$$

whence

$$\log \frac{1}{q} . \log \frac{1}{q_1} = (\pi \log \epsilon)^2$$

or by taking logarithms

$$\log \text{ of } \log \frac{1}{q} + \log \text{ of } \log \frac{1}{q_1} = 0{\cdot}269868368 \ \ldots \quad (c)$$

Several tables of $q$, $\log q$ and $\log$ of $\log \frac{1}{q}$ have been computed, viz. :—

| | | |
|---|---|---|
| 1840. | Jacobi. | Log $q$ to 5 places from 0° to 90° at intervals of 0°·1. (*Crelle's Journal*, vol. xxvi. p. 93.) |
| 1841. | Loxhay. | Log of $\log \frac{1}{q}$ to 12 or 14 places from 0° to 45° at intervals of 0°·1. (In Verhulst's *Fonctions Elliptiques*, Bruxelles.) |
| 1860. | Meissel. | Log $q$ to 8 places from 0° to 90° at intervals of 0°·1. (*Sammlung mathematischer Tafeln* 1, Iserlohn.) |
| 1870. | Bertrand. | Log $q$ to 5 places from 0° to 90° at intervals of 5′, and of log of $\log \frac{1}{q}$. (*Calcul Intégral*, Paris.) |
| 1877. | Glaisher. | Of $q$ and log $q$ to 8 places for every degree from 0° to 89°. (*Monthly Notices, R.A.S.*, vol. xxxvii. pp. 372–4.) |
| 1879. | Schömlich. | Log $q$ to 5 places for every degree. (*Vorlesungen der höheren Analysis*, p. 448.) |
| 1898. | Levy. | Log $q$ to 5 places from Bertrand *C.I.* (*Fonctions Elliptiques*, Paris.) |
| 1901. | Hoüel. | Log $q$ to 4 places for every centesimal degree. (*Tables Numériques*, Paris.) |

(See also Glaisher, Tables, *Ency. Brit.*)

The defect of those tables of the above which have sufficient decimals * for astronomical purposes is their lack of differences, so that on each occasion the tables are used the interpolation would be a longer work than a computation of the function from one of the above formulæ.

I had therefore commenced a table to every minute of the first 45°, giving $q$ to ten places of decimals, with log $q$ and log of $\log \frac{1}{q}$

* I have not seen Meissel's Table.

es. This work was not persevered in for several tables of not very frequent use they would occupy pace. Interpolations would still require the use of nces in the most favourable part of the table (near whilst for small angles interpolation fails altogether

f $\log q$ and log of $\log \frac{1}{q}$. The slow rate of change

$$\frac{q}{\tan^2 \frac{\theta}{2}}$$

t the tabulation of that quantity would suit all irements.

imens of the earlier computed tables are given :—

| $q$ | Δ | $\log q$. | Δ | $\log$ of $\log \frac{1}{q}$. | Δ |
|---|---|---|---|---|---|
| 00,0000,000, | 53 | $\infty$ | | $\infty$ | |
| 053 | 159 | $\bar{9}$·7233.3226 | Too large to be tabulated. | 0·9178.5552 | Too large to be tabulated. |
| 212 | 264 | $\bar{8}$·3253.9227 | | ·8850.5619 | |
| 476 | 370 | ·6775 7482 | | ·8646.5494 | |
| 846 | 476 | $\bar{8}$·9274 5233 | | ·8495.7588 | |
| 1.322 | 582 | $\bar{7}$·1212.7241 | | ·8375.0811 | |
| 1.904 | 687 | ·2796.3497 | | ·8273.9286 | |
| 2.591 | 794 | ·4135.2863 | | ·8186.5281 | |
| 3.385 | 899 | ·5295.1262 | | ·8109.3699 | |
| 4.284 | [illegible] | ·6318.1377 | | ·8040.1548 | |

Vega's 10-place tables (Italian edition) were used, hence the tenth decimal is somewhat doubtful. The calculations were checked by differencing. The higher differences in several parts of the table suggested alterations of a few units in the last decimal place of several of the functions; these alterations were adopted, so that finally the run of the differences was smooth enough. Four orders of differences were then changed into differential coefficients and divided by 1, 2, 6 and 24 respectively. The logarithms of the resulting numbers are given. This makes the use of the table in actual practice exceedingly easy, as simple powers of the decimal portion of any given argument are only wanted. I could not derive a workable formula showing the literal forms of the differential coefficients, so that the numbers given probably lack rigid accuracy. Numerous tests, taking the argument positively and negatively (*e.g.* 23°+6′ and 24°−54′) seldom differed by more than one or two units in the last decimal place. Even so $q$ will be furnished correctly to at least 11 places of decimals, an accuracy more than sufficient for any practical requirements.

Log $q$ was computed from the working formula

$$\log q = \log \frac{l}{2} + 2Mq^4 - 3Mq^8 \qquad (M = 0{\cdot}434\ldots)$$

In this formula the approximate value of $q$ required was taken from Glaisher's table already mentioned. The term $3Mq^8$ amounts to one unit in the 11th place of decimals of log $q$ at 45°. The total correction to the approximate formula

$$\log q = \log \frac{l}{2}$$

is shown in a table at the end of this paper. It is arranged so that to seven places of decimals no interpolation is necessary.

*Auxiliary Table for the Computation of log q.*

$$f(\theta) = \log\left[\frac{q}{\left(\tan\frac{\theta}{2}\right)^2}\right]$$

| $\theta$ | $f(\theta)$. | $\log f^{I}(\theta)$. | $\log \frac{1}{2}f^{II}(\theta)$. | $\log \frac{1}{6}f^{III}(\theta)$. | $\log \frac{1}{24}f^{IV}(\theta)$. |
|---|---|---|---|---|---|
| 0° | 9·3979400,087 | $-\infty$ | $-\infty$ | $-\infty$ | 0·77 |
| 1 | 00,093 | 1·3979 | 1·5798 | 1·3979 | ·78 |
| 2 | 00,187 | 2·3032 | 2·1790 | 1·7076 | ·79 |
| 3 | 00,597 | 2·8325 | 2·5328 | 1·8808 | ·80 |
| 4 | 01,701 | 3·2087 | 2·7832 | 2·0004 | ·81 |
| 5 | 04,033 | 3·4998 | 2·9777 | 2·1038 | ·82 |
| 6 | 08,278 | 3·7380 | 3·1374 | 2·1875 | ·83 |
| 7 | 15,281 | 3·9397 | 3·2728 | 2·2577 | ·84 |
| 8 | 26,046 | 4·1147 | 3·3906 | 2·3181 | ·85 |
| 9 | 9·3979441,741 | 4·2693 | 3·4947 | 2·3729 | 0·86 |

| | $\log f^{I}(\theta)$. | $\log \frac{1}{2} f^{II}(\theta)$. | $\log \frac{1}{3} f^{III}(\theta)$. | $\log \frac{1}{4} f^{IV}(\theta)$. |
|---|---|---|---|---|
| 163,698 | 4·40782 | 3·5884 | 2·4232 | 0·87 |
| 193,421 | 4·53340 | 3·6735 | 2·4698 | ·88 |
| 232,589 | 4·64831 | 3·7516 | 2·5119 | ·90 |
| 283,061 | 4·75426 | 3·8239 | 2·5527 | ·91 |
| 346,882 | 4·85264 | 3·89137 | 2·5911 | ·92 |
| 426,293 | 4·944492 | 3·95453 | 2·6274 | ·93 |
| 523,733 | 5·030677 | 4·01406 | 2·6618 | ·95 |
| 641,848 | 5·111897 | 4·07041 | 2·6955 | 0·97 |
| 783,503 | 5·188749 | 4·12405 | 2·7284 | 1·00 |
| 951,790 | 5·261719 | 4·17522 | 2·7597 | 1·02 |
| 1,150,038 | 5·331227 | 4·22425 | 2·7903 | 1·04 |
| 1,381,826 | 5·397617 | 4·27131 | 2·8209 | ·06 |
| 1,650,991 | 5·461199 | 4·31666 | 2·8506 | ·08 |
| 1,961,647 | 5·522241 | 4·36048 | 2·8797 | ·10 |
| 2,318,196 | 5·580968 | 4·40290 | 2·9090 | ·12 |
| 2,725,345 | 5·637588 | 4·44406 | 2·9375 | ·15 |
| 3,188,124 | 5·692279 | 4·48411 | 2·9661 | ·18 |
| 3,711,906 | 5·7452029 | 4·52313 | 2·9943 | ·20 |
| 4,302,426 | 5·7965022 | 4·56126 | 3·0224 | ·23 |
| 4,965,805 | 5·8463056 | 4·59852 | 3·0504 | 1·26 |
| 5,708,569 | 5·8947253 | 4·63502 | 3·0785 | 1·28 |

To find $q$ we have

$$\log q = \log \tan^2 \frac{\theta + h}{2} + f(\theta) + h f^{I}(\theta) + h^2 \tfrac{1}{2} f^{II}(\theta) + h^3 \tfrac{1}{3} f^{III}(\theta) + h^4 \tfrac{1}{4} f^{IV}(\theta).$$

As an example let us compute $\log q$ for $\theta = 44° 4' 18''{\cdot}31$ (or $44° + {\cdot}071753$ or $45° - {\cdot}928247$).

| | | | | |
|---|---|---|---|---|
| Table $44°$ = | | 9·400,8649,221. | $45°$ = | 9·401,1750,169 |
| 1st diff. | = + | 213,252. | = − | 3001,055 |
| 2nd „ | = + | 648. | = + | 116,593 |
| 3rd „ | = + | 1. | = − | 2,630 |
| 4th „ | = + | 0. | = + | 46 |
| | | 9·400,8863,122. | | 9·400,8863,123 |

and $\log \tan^2 \frac{\theta}{2} = 9{\cdot}214,3839$ gives $\log q$ 8·615,2702.

A recent interesting application of the nome to astronomical formulæ has been made by Professor G. W. Hill in the secular perturbations of the planets (*Amer. Journ. Mathem.* vol. xxiii. No. 4, and *Astron. Journ.* No. 511). Professor Hill shows that the secular perturbations depend on two quantities, $\mathfrak{K}$ and $\mathfrak{L}$, which have the following values in the notation of this paper :

$$\left.\begin{aligned} \mathfrak{K} &= \frac{K}{k^2_1} = \frac{1}{k^2_1}(1 + 2q + 2q^4 + \text{ &c.})^2 \\ \mathfrak{L} &= \frac{K - E}{k^2 k^2_1} = \frac{8(q - 4q^4 + 9q^9 - \text{&c.})}{(Kk_1)^{\frac{1}{2}} k^2} \end{aligned}\right\} \quad \ldots \quad \ldots \quad (A)$$

In these formulæ, if $\theta$ $(= \sin^{-1} k)$ is under $45°$, $q^9$ will not affect the 11th decimal, and may be neglected without appreciable error.

When $\theta$ exceeds $45°$, $q$ increases in value, and its 9th power may become sensible. If so, it may be better to avoid going beyond $45°$ by the following device.

From

$$q = \epsilon^{-\pi \frac{K_1}{K}}$$

we have

$$K_1 = K \frac{\log \frac{1}{q}}{\pi \log \epsilon} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (B)$$

and from

$$E_1 K + E K_1 - K K_1 = \frac{2}{\pi}$$

$$\zeta_1 - E_1 = \frac{1}{K}\left(EK_1 - \frac{2}{\pi}\right)$$

$$= \frac{1}{K}\left(EK\frac{\log\frac{1}{q}}{\pi \log \epsilon} - \frac{2}{\pi}\right) \quad \ldots \quad \ldots \quad (B_1)$$

$$EK = \frac{1 + 3^2q^2 + 5^2q^6 + \&c.}{1 + \quad q^2 + \quad q^6 + \&c.}$$

$$\frac{1}{\pi \log \epsilon} = 9{\cdot}86506582, \quad \frac{2}{\pi} = 0{\cdot}63661977).$$

the above formulæ to the example given by Pro-
*stron. Journ.* No. 512), we have $\theta = 45^\circ\ 55'\ 41''{\cdot}69$
$4'\ 18''{\cdot}31$. Log $q$ has already been computed for
gle $(44^\circ\ 4'\ 18''{\cdot}31)$ and by equation $(c)$, or by the
ne bottom of the table, p. 498, we get log $q$ for
8.

ase to compute $\mathfrak{K}$ and $\mathfrak{L}$ it would obviously be
e the set of formulæ (A), but to exhibit the use of
e formulæ (B and $B_1$) they are employed.

log of $\log \frac{1}{q} = 0{\cdot}1413650$

$1{\cdot}082470806$
$\quad 5782$

$\log \frac{1}{\pi \log \epsilon} = 9{\cdot}8650658$

$1{\cdot}08247658\overline{8}$ $\qquad$ $0{\cdot}0064308 = (a)$

Several applications of the nome occur in Gyldén's works; one of these is the subject of Dr. Glaisher's paper in the *Monthly Notices*.

As is well known, the elliptic integrals can be used in computing the $b^{(0)}_{\frac{1}{2}}$ coefficients in the development of the perturbative function, thus:

$$b^{(0)}_{\frac{1}{2}} = 2\mathrm{K}. \qquad (a = k)$$

$$b^{(1)}_{\frac{1}{2}} = \frac{2(\mathrm{K}-\mathrm{E})}{k} = \frac{16(q - 4q^4 + 9q^9 - \&c.)}{\mathrm{K}^{\frac{1}{2}} k k_1^{\frac{1}{2}}}$$

$$\alpha \frac{db^{(0)}_{\frac{1}{2}}}{d\alpha} = \frac{2(\mathrm{E} - k_1^2\mathrm{K})}{k_1^2} = \frac{16(q + 4q^4 + 9q^9 + \&c.)}{\mathrm{K}^{\frac{1}{2}} k_1^2}$$

With the major planets $\theta = \sin^{-1}\alpha$ only exceeds 45° in the case of *Venus* and the Earth, and then only slightly ($\theta = 46°\ 19'\ 49''{\cdot}04$ after Le Verrier). For the latter angle, $q$ is 0·04616097, so that $q^9$ is entirely negligible. If the ratio $\alpha$ gave a very large angle for $\theta$, the formulæ already quoted can be adapted so that the computation may be made with a value of $q$ for $90° - \theta$. It is somewhat doubtful if the use of the nome in this connection, except in a few special cases, would be found so useful as the Bruns-Harzer method of mechanical quadratures. (See *Die Säcularen Veränderungen der Bahnen der grossen Planeten*, by Paul Harzer, p. 60, also a paper by the same author in the *Mém. de l'Acad. Imp. de St.-Pétersbourg*, 1886, p. 28).

Applications to Geodetical Astronomy will be found in Halphen, *Fonctions Elliptiques*, vol. ii., and in Hoüel, *Tables Numériques*.

Incidentally the following table of log $q$ and log of log $\frac{1}{q}$ each to 10 places was prepared. Log $q$ is new, but log of log $\frac{1}{q}$ has been taken from Loxhay's table; it is therefore possible that there is a want of rigid correspondence between the two sets of numbers, as the values of log $q$ have not been corrected in their last decimals by differencing.

*Table of log q and log of log* $\frac{1}{q}$.

| $\theta$. | Log $q$. | Log of log $\frac{1}{q}$ | $\theta$. | Log $q$. | Log of log $\frac{1}{q}$ |
|---|---|---|---|---|---|
| ° | | | ° | | |
| 0 | $-\infty$ | | 5 | 6·6781266244 | 5213830738 |
| 1 | 5·2796568024 | 0·6739735756 | 6 | 6·8367323424 | 5001359410 |
| 2 | 5·8817829559 | 6147092317 | 7 | 6·9709136917 | 4813116479 |
| 3 | 6·2340757853 | 5758715761 | 8 | 7·0872300618 | 4643061837 |
| 4 | 6·4841077801 | 5460355533 | 9 | 7·1899124762 | 0·4487198467 |

| | Log of $\log\frac{1}{q}$. | $\theta$. | Log $q$. | Log of $\log\frac{1}{q}$. |
|---|---|---|---|---|
| 44 | 0·4342734299 | 28° | 8·1919023594 | 2572218795 |
| 97 | 4207636216 | 29 | 8·2237426822 | 0·2495058801 |
| 123 | 4080374126 | | | |
| 167 | 3959765166 | 30 | 8·2546057618 | 0·2418935379 |
| 10 | 3844874259 | 31 | 8·2845603835 | 2343754355 |
| 144 | 3734948114 | 32 | 8·3136689325 | 2269428411 |
| 104 | 3629369962 | 33 | 8·3419881948 | 2195876184 |
| 130 | 3527627640 | 34 | 8·3695700358 | 2123021482 |
| 190 | 3429290534 | 35 | 8·3964619813 | 2050792612 |
| 108 | 0·3333992574 | 36 | 8·4227077213 | 1979121773 |
| | | 37 | 8·4483475420 | 1907944537 |
| | | 38 | 8·4734187025 | 1837199374 |
| 161 | 0·3241419463 | 39 | 8·4979557644 | 0·1766827230 |
| 138 | 3151298923 | | | |
| 164 | 3063393105 | 40 | 8·5219908792 | 0·1696771141 |
| 198 | 0·2977492718 | 41 | 8·5455540438 | 1626975885 |
| 119 | 2893412243 | 42 | 8·5686733251 | 1557387650 |
| 192 | 2810986181 | 43 | 8·5913750603 | 1487953733 |
| 129 | 2730065964 | 44 | 8·6136840351 | 1418622246 |
| 162 | 2650517442 | 45 | 8·6356236462 | 0·1349341840 |

*showing Error of the Assumption that* $\log q = \log\frac{1}{2}$.

[In units of the 7th place of decimals.]

| $\log q = \log\frac{1}{2} +$. | $\theta$. | $\log q = \log\frac{1}{2} +$. |
|---|---|---|

| $\theta$. | $\log q = \log \frac{l}{2} +$. | $\theta$. | $\log q = \log \frac{l}{2} +$. |
|---|---|---|---|
| ° ′ | | ° | |
| 40 0 | 10·636 | 42 40 | 18·802 |
| 10 | 11·031 | 50 | 19·467 |
| 20 | 11·439 | 43 0 | 20·152 |
| 30 | 11·961 | 10 | 20·859 |
| 40 | 12·297 | 20 | 21·588 |
| 50 | 12·748 | 30 | 22·341 |
| 41 0 | 13·214 | 40 | 23·119 |
| 10 | 13·695 | 50 | 23·921 |
| 20 | 14·192 | 44 0 | 24·749 |
| 30 | 14·705 | 10 | 25·602 |
| 40 | 15·235 | 20 | 26·483 |
| 50 | 15·784 | 30 | 27·391 |
| 42 0 | 16·350 | 40 | 28·328 |
| ... 10 | 16·934 | 50 | 29·294 |
| 20 | 17·537 | 45 0 | 30·291 |
| 30 | 18·159 | | |

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## *Reductions of Extra Meridian Observations of Planets.*

By P. H. Cowell.

(*Communicated by the Astronomer Royal.*)

The following method of reducing observations of planets with the altazimuth has been brought into use at the Royal Observatory, Greenwich.

From the observation of, let us suppose, the Moon, after correcting for instrumental errors and refraction, we have the data:

(1) At time $t_1$ the Moon's limb was on the standard azimuth (*e.g.* prime vertical, 45° from meridian, &c.)

(2) At time $t_2$ the Moon's limb was at zenith distance $z$, after allowing for refraction.

The method aims at transforming these data into the following:—

(1) At time T the Moon's centre was on the standard azimuth as seen from the Earth's centre.

(2) At the same time T the Moon's centre, as seen from the centre of the Earth, was at an inclination Z to the direction of gravity at Greenwich.

It is clear that when this transformation has been accomplished with argument Z we can obtain the Moon's geocentric polar distance and hour-angle; and, combining the latter with T, the right ascension also.

The quantities to be calculated are $T-t_1$ and $Z-z$; the calculation of these quantities is equivalent to reducing the Moon to a star: that is to say, it corrects for the finite parallax and finite diameter.

The method is perfectly general, and is suitable for any azimuth. The computation has been assisted by forming tables for azimuths 90°, 80°, 70°, 60°, and 45°, which are alone used at Greenwich. A special case is given below as illustration; the reasoning and the formulæ apply to any azimuth, the computing to the particular observation.

| Description of Term. | Formula. | Numerical Value. |
|---|---|---|
| Approximate azimuth motion in one lunar second | $15 \sin \Delta \cos S$ | ... |
| Correction for motion in R.A. ... ... ... | $\frac{601{\cdot}643 - 579{\cdot}682 - \mu_s}{579{\cdot}682}$ | +0·00336 |
| Correction for motion in N.P.D. ... ... ... | $-\frac{\sin c \sin A \operatorname{cosec} \Delta}{579{\cdot}682}$ | −0·001133 |
| B ... ... ... ... | ... | ... |
| Semidiameter ... ... | $+1L, -2L$ | ... |
| Figure of Earth term ... | $+0{\cdot}003250 \sin A$ | +0·003250 |
| Curvature correction ... | $+\frac{15^2}{2 \times 206265} t^2 \cos \Delta \sin c \sin A$ | ... |
| A ... ... ... ... | ... | ... |
| $T-t_1$ ... ... ... | $\frac{A}{B} \times \frac{601{\cdot}643}{579{\cdot}682}$ | ... |
| $t_1$ ... ... ... ... | ... | ... |
| T ... ... ... ... | ... | ... |
| $t_2$ ... ... ... ... | ... | ... |
| $T-t_2$ ... ... ... | ... | ... |
| Approximate zenithal motion in one sidereal second | $+15 \sin c \sin A \frac{579{\cdot}682}{601{\cdot}643}$ | ... |
| Correction for motion in R.A. ... ... ... | $\frac{601{\cdot}643 - 579{\cdot}682 - \mu^s}{579{\cdot}682}$ | +0·00336 |
| Correction for motion in N.P.D. ... ... ... | $\frac{\cos S}{601{\cdot}643}$ | +0·00125 |
| B' ... ... ... ... | ... | ... |
| Motion in time $T-t_2$ ... | $B'(T-t_2)$ | ... |
| Semidiameter ... ... | $+UL, -LL$ | ... |
| Observed z.d., corrected for refraction | ... | ... |
| Approximate correction for parallax | $-p\rho \sin(\varepsilon + \zeta)$ | ... |
| Airy correction ... ... | ... | ... |
| Z ... ... ... ... | ... | ... |

For planets other than Moon replace 579·682

1899 April 17$^d$ 11$^h$ 13$^m$·3. Moon on Prime Vertical, West of Meridian.

| | | | |
|---|---|---|---|
| $c$ | colatitude ... ... ... ... ... | | 38° 31′ 24″ |
| A | azimuth reckoned from south towards west | + | 90° |
| $\Delta$ | north polar distance ... ... ... | = | 71° 37′ 35′ |
| S | angle at planet subtended by line joining zenith to pole. | | |
| $\mu_\alpha$ | motion in R.A. in 10 solar minutes ... | + | 20$^s$·015 |
| $\mu_\Delta$ | motion in N.P.D. in 10 solar minutes ... | + | 81″·14 |
| $p$ | parallax ... ... ... ... ... | | 54′ 16″·39 |

| Precept. | Term. | Remarks. |
|---|---|---|
| ... | 10·7407 | For other planets read "one sidereal second." |
| × 15 sin $\Delta$ cos S | +0·0361 | ... |
| × $\mu_\Delta$ | −0·0919 | ... |
| sum | 10·6849 | |
| ... | +888″·82 | ... |
| × $p$ | + 10·58 | Compression $\frac{1}{303}$. |
| ... | + 0·74 | $t = \frac{A}{B}$. |
| sum | +900·14 | ... |
| ... | + 87$^s$·43 | ... |
| ... | 10 55 27·41 | ... |
| ... | 10 56 54·84 | ... |
| ... | 10 56 44·34 | ... |
| ... | +10·50 | ... |
| ... | +9″·001 | ... |
| × 15 sin $c$ sin A $\frac{579·682}{601·643}$ | +0·030 | ... |
| × $\mu_\Delta$ | +0·101 | ... |
| sum | +9·132 | ... |
| ... | + $^c$ 1′ 35″·89 | ... |
| ... | − 14 48·82 | ... |
| ... | +67 17 40·49 | ... |
| ... | − 49 57·93 | $\zeta = -11′\ 11″·7 \cos A$. $\log \rho = 9·999119$. |
| ... | − 0·11 | For Moon only. |
| sum | 66 14 29·52 | |

by 601·643 and omit the Airy correction.

thod of the reduction is sufficiently explained
cond columns of the above specimen computatic
mbers 601·643 and 579·682 that appear in the
the numbers of sidereal and lunar seconds respe
minutes.
mulæ are easily proved ; an investigation of th
is given below.
e figure of the Earth a compression $\frac{1}{300}$ is use
ed for the height of the observatory above th

ry correction is the excess of

$$-\sin^{-1}[\sin p(\rho \sin z + \mu)],$$

rrection for parallax and semidiameter, over

$$-p\rho \sin z - \sin^{-1}(\mu \sin p),$$

been applied under the names of "approxima
parallax" and "semidiameter." $\mu$ here denot
e Moon's diameter to the Earth's equatorial dia
be considered negative for the upper limb
value is 0·273. The formula is easily reduced

$$\frac{206265''}{6} \sin^3 p \sin z[0{\cdot}78 - \sin z(\pm{\cdot}82 + \sin z)]$$

er and upper limbs respectively.

the other hand, it may prove more expedient to examine the practical problems which arise individually and in a more simple and direct manner. The possibility of proceeding in this way constitutes one of the vital advantages of the photographic method as compared with methods more familiar in the past, wherein the observations, once made, could not be reconsidered or repeated.

2. The principal conclusions at which I had arrived were not disputed by Mr. Hinks, who, in a desire to avoid reference to the usual theory of errors, employed a line of argument of which it seems difficult to assess the precise value. It may be pointed out, however, that even if all that involved the language of the ordinary theory of errors had been suppressed in my paper the comparative table of discordances ($P_1$, p. 624) would suffice to prove the main point in question. But there is one small point, in no way affecting my conclusions, on which Mr. Hinks has expressed himself at variance with me. He says ($H_1$, p. 136), "I do not therefore find myself in agreement with Mr. Plummer when he says: 'We may follow M. Lœwy in denoting the accidental and systematic errors by $E_a$ and $E_s$ respectively, and the total probable error by $E_t$, and admit that $E_t^2 = E_a^2 + E_s^2$.' This is indeed in obvious contradiction to his conclusion that there is a striking compensation of errors when the plate is measured in reversed positions. . . ." I believe that this criticism is due simply to a slight misconception of the policy underlying my paper. In § 5 ($P_1$), where the words quoted by Mr. Hinks occur, I was following M. Lœwy's views as closely as possible. There was no proof at that stage that M. Lœwy was essentially wrong. Afterwards, in its logical place, the application of the law is denied in sufficiently clear terms. Thus in § 11 ($P_1$, p. 625) ". . . in general it" (*i.e.* the error removed by reversing the plate) "will not obey the axioms on which the ordinary theory of errors is founded," and again in § 12 ($P_1$, p. 626): "Evidently we must regard as the unit of measurement, *not* a measure made in a single orientation, *but* the mean of two effected on the plate in the direct and reversed position." These statements sufficiently cover § 5 and remove my responsibility for any preliminary statement made there.

3. But though this explains the point raised by Mr. Hinks, and shows that we are really in agreement, the point may usefully be considered further, and its examination will serve as an introduction to the remarks to be made on M. Lœwy's papers. If we have an error $t$ which must be considered as made up of two parts $a$ and $s$, so that $t = a + s$, then

$$t^2 = a^2 + 2as + s^2.$$

It follows that if mean values are taken of both sides of the equation, in a purely statistical sense and with an obvious notation,

$$\epsilon_t^2 = \epsilon_a^2 + \epsilon_s^2$$

provided that (1) $a$ and $s$ are really independent, and (2) positive and negative values of $a$ are equally likely to the same amount. The formula does hold then in a certain sense for errors of mean square. But if we deduce a corresponding formula for probable errors on the supposition that the probable error bears a fixed ratio to the error of mean square, the result will be not merely wrong but unmeaning, unless both the errors $a$ and $s$ obey certain laws too well known to make it necessary to specify them here. And even if we *define* a probable error as bearing the ratio to the error of mean square of ·6745 : 1, which would be consistent with the ordinary theory, it would still remain true that the resulting formula would have no useful meaning, and no useful deduction whatever could be derived from it. Similarly it is easy to assume a more extended formula, such as

$$\epsilon_t^2 = \frac{\epsilon_1^2}{m_1} + \frac{\epsilon_2^2}{m_2} + \frac{\epsilon_3^2}{m_3} + \ldots$$

when a number of sources of error are in question, and there is no formal difficulty in deriving a set of constants from a sufficient number of equations which are to be obtained by varying the conditions of observation. But, again, it is quite obvious that the result can bear no useful meaning unless we are prepared to subscribe to certain articles of belief as to the nature of the sources of error involved. And there is a further difficulty in practice. The probable errors in the several cases can be determined easily enough, but we can seldom ascribe to them a high degree of precision, and that for several reasons, such as the finite number of the residuals on which they are based. Consequently the more complicated the formula assumed the more will errors accumulate in the determination of the constants, until from this cause alone an absolutely fallacious result will be obtained.

4. The principles here laid down will probably not be disputed : on the contrary, they are more likely to be considered too obvious to need expression. But they are precisely those which the method of M. Lœwy's first memoir disregarded ; and in his later work the same faulty method is pushed to what appear to me extravagant lengths. Whenever a discrepancy arises in the application of the formula it is fatally easy to assume a fresh source of error and to add a term $\epsilon_r^2$ multiplied by some arbitrary numerical factor. But it is difficult to be assured that the final formula is really in accordance with the laws of probability, or that it is not vitiated by a mass of accumulated error. In the absence of such assurance the results cannot command our confidence. M. Lœwy has assumed the possibility of constructing a formula which shall include all possible sources of error and meet all cases. To speak shortly, I am not prepared to admit that possibility. A too complicated formula of the kind in question seems to me to fall of its own weight.

5. My previous paper was confined to a consideration of the accuracy of the measures of photographic images, and was not concerned with the accuracy of the positions of the images themselves. Although M. Lœwy's later work is devoted to the investigation of the precision of measured coordinates in the wider sense, and to the examination of a number of important questions, I do not intend to enlarge the area of discussion. Mr. Hinks seems to go rather too far when he says ($H_1$, p. 137): "It is, then, of no consequence to examine elaborately the divergences from the mean of settings on a single exposure." Undoubtedly this is only a question of a preliminary character, and its solution will not carry us very far. But it is none the less an important one, and appears fundamental in M. Lœwy's method of inquiry. To put the matter as briefly as possible, the main practical conclusion of my former paper was that no essential advantage is to be gained by measuring the position of a single image in more than two orientations of the plate, and that opposite orientations (*e.g.* 0° and 180°) should be chosen. This contention was opposed to M. Lœwy's view that measures in four orientations were necessary, and was based partly on the fact that M. Lœwy's general formula did not apply to measures made in opposite orientations. From this it appeared that *one class of error* was eliminated by reversing the plate. In an Avant-propos, in which he has done me the honour to make reference (but in no sense a reply) to my criticism, M. Lœwy attributes to me the belief that "il suffit, pour tenir compte des erreurs systématiques et pour les éliminer, de faire des mesures dans deux positions de la plaque différentes de 180°." This rather overstates my view, for I said distinctly ($P_1$, p. 626): "I do not mean to say that the whole error, apart from what is purely accidental, can be removed by simply reversing the plate."

6. Before I leave the Avant-propos, another passage may be mentioned which seems to indicate a misapprehension in M. Lœwy's mind. Referring to his third memoir, he says: "Cette troisième recherche . . . a . . . révélé ainsi l'existence d'une nouvelle source d'erreur. Contrairement au reproche d'avoir attribué, d'après mes formules, des erreurs probables trop fortes aux résultats, il est arrivé ce qui était à redouter, que cette précision a été surestimée. Cette dernière source d'erreur provient de la déformation de la gélatine. . . . Il résulte de ce fait une inexactitude accidentelle . . . indépendante d'ailleurs de toutes les opérations de mesure." I may be wrong in supposing that this passage is suggested by my "reproche," though the context seems to support that view. But if I am not, it suggests that possibly some slight confusion of ideas may be involved. Clearly it is no answer to the question how accurate are the measures to say that inexactitudes exist which are independent of the process of measurement. As a matter of fact the passage quoted does not apply to my paper at all. My third conclusion ($P_1$, p. 628) was: "If M. Lœwy's estimate of the precision

so made be accepted, it does not follow that it is
to repeat the measures as many times as he thinks
The grounds on which this opinion was based are
9 ($P_1$, p. 623), in which the reason assigned is pre-
systematic error," *i.e.* "l'inexactitude indépendante
s opérations de mesure."

e beginning of his second memoir M. Lœwy dis-
wo parts in the total error of a measure, the acciden-
systematic, and subdivides the latter into (1) $\epsilon_{s_1}$ the
he calls "l'erreur permanente physiologique," and
error which "provient d'une appréciation erronée du
sque." He seems to consider $\epsilon_{s_1}$ to be of a magnitude
enter into the account, an opinion of which some-
e said in § 12. With regard to $\epsilon_{s_2}$ he says ($L_2$, p. 11):
e les deux valeurs de $\epsilon_{s_2}$ comme étant complètement
es l'une de l'autre aussi bien en signe qu'en grandeur,
ité de l'observateur disparaissant ici complètement."
n rapid reversal is possible, he admits, however, that
produire certaines compensations avantageuses d'une
reurs systématiques $\epsilon_{s_1}$, si toutefois celles-ci existent."

be suggested that a practical inference, such as that
l means ought to be provided for making a rapid
sible if the best result is to be obtained, is perhaps of
e than an elaborate formula based on the principle
mieux toujours attribuer aux sources d'erreurs leur
effet."

pears that the second memoir was practically com-

others, and the numbers which he has deduced from the plate P must all lie under the same suspicion. If the argument be admitted, the weight to be attached to the results of the first two memoirs is small indeed.

9. It may be remarked at this point that M. Lœwy in his first two memoirs has sought to erect a vast edifice on a singularly slender foundation—in fact, on a single plate, if I have not misunderstood him. It is useless in a matter of this kind to seek support in vague appeals to "experience." On the other hand the strength of the critical position depends on the fact that the objections which have been raised have been based on M. Lœwy's own material. Now, as to these observations, some comments must be made. M. Lœwy remarks ($L_2$, p. 11): "En ce qui concerne le cliché P, quelques incertitudes très légères se sont révélées au début des mesures, où les observateurs A et B n'avaient pas la sûreté d'une pratique prolongée, mais ultérieurement, pour tous les deux, l'erreur $\epsilon_{t_1}$ s'est complètement évanouie." It is unfortunate that a research which pretends to a fundamental character should have been based on the work of inexperienced measurers. Another remark of M. Lœwy's is also noteworthy ($L_2$, p. 47): "Je dois à cette occasion faire remarquer que l'observateur B se trouvant absent pendant plusieurs jours, quelques-unes des mesures, huit ou dix séries, ont été effectuées par l'observateur A, substitution qui . . . ne donne lieu à aucun inconvénient." This is also unfortunate, and reveals the gratuitous nature of M. Lœwy's assumption that a change of orientation with a single observer is equivalent to a change of observers. It may also help to explain the notable discontinuities which I found in my former paper ($P_1$, § 7)—and Mr. Hinks confirms me—to exist in the residuals of B in certain orientations. But the fact that measures actually made by A were in effect labelled as those of B stands in no need of comment.

10. One very considerable concession M. Lœwy has made. He has not only given a general formula for the probable error according to his own ideas and assumptions, but he has also given a second solution of the problem which is based on the means of measures effected in opposite orientations of the plate. He admits ($L_2$, p. 57) that "cette formule aboutit pour $\epsilon_t^m$" (the probable error) "à des valeurs inférieures à celles que donnerait la formule (C)." But he contests its validity on two grounds: "Non seulement la seconde solution ne peut être appliquée aux opérations de mesure exécutées dans une seule orientation, mais elle donne un résultat trop faible et trop éloigné de la vérité." The latter reason is a mere statement and nothing more. The former objection is irrelevant, for my whole point is that the mean of measures in opposite orientations is to be regarded as the unit of measurement. I do not admit the possibility in general of constructing a single formula which shall represent the accuracy of single measures and those made in

osen orientations, because there is no continuity
e two cases. And therefore, when M. Lœwy
his second solution by the addition of numerous
can be no agreement with his method of procedure,
results be accepted of which he says ($L_2$, p. 59):
e de formules (G) ainsi amélioré devient maintenant
tous les cas, même pour les mesures faites dans une
ation de la plaque." This contradicts the very hypo-
right or wrong) on which the formulæ are based, and
need not be discussed further.

ain points in M. Lœwy's third memoir may now
considered. His object here is to compare the
oordinates with those deduced from the meridian
s of *étoiles de repère*, and the material for discussion is
measures effected on an *Eros* plate designated BI.
ended to go beyond the limits imposed in § 5, except
ne point which presents itself at the end of the
M. Lœwy finds that the probable discordance
scissæ is $0''{\cdot}167$ when determined by direct com-
$0''{\cdot}129$ when calculated *a priori* from his formula.
that ($L_3$, p. 115) "la divergence . . . n'est pas en
le." Now, clearly it might be caused by a systematic
has been overlooked, of probable magnitude $0''{\cdot}10$.
need to lay any great stress on the discrepancy,
t be accounted for in several ways; though M. Lœwy
inconsistent here when his previous treatment of
rences is borne in mind. But surely he is not justified
"L'accord entre les erreurs prévues et celles qui se
réellement semble apporter une démonstration

Personality which I have constructed by subtracting from each measure the mean for each observer, and adding the results for each orientation and dividing the sums by 43, the number of the stars. The numbers in the first column are those of the sections of Tableau III., corresponding to the six images whose ordinates were measured.

*Table of Personality.*

| Tableau III. | A | | | | B | | | |
|---|---|---|---|---|---|---|---|---|
| | 0°. | 180°. | 90°. | 270°. | 0°. | 180°. | 90°. | 270°. |
| | ″ | ″ | ″ | ″ | ″ | ″ | ″ | ″ |
| 2 | +0·092 | −0·102 | +0·053 | −0·042 | +0·070 | −0·037 | +0·029 | −0·062 |
| 3 | + ·096 | − ·117 | + ·077 | − ·056 | + ·076 | − ·044 | + ·020 | − ·050 |
| 4 | + ·070 | − ·103 | + ·073 | − ·038 | + ·059 | − ·019 | + ·032 | − ·071 |
| 5 | + ·092 | − ·095 | + ·071 | − ·066 | + ·086 | − ·055 | + ·050 | − ·081 |
| 6 | + ·113 | − ·112 | + ·083 | − ·085 | + ·075 | − ·046 | + ·038 | − ·068 |
| 7 | + ·114 | − ·120 | + ·076 | − ·069 | + ·075 | − ·051 | + ·038 | − ·064 |
| Means = | + ·096 | − ·108 | + ·072 | − ·059 | + ·073 | − ·042 | + ·035 | − ·066 |

In the face of these figures can M. Lœwy's denial of the existence of the "erreur physiologique" be maintained? But perhaps he will say they are small. "Valeur appréciable" is a relative term, it is true. But there is an answer to this objection which seems to me final. *The magnitudes of these constant errors are in many cases sufficient practically to control the signs of the residuals.* Thus for the observer A's measures in orientation 0° *only* 40 *residuals are negative in a total of* 258! Surely so great an "écart" ought to be attributed to a cause.

13. The task of discussing a set of residuals is always a delicate one, and M. Lœwy has not avoided a serious error. The true principle was expressed admirably by Gauss, and in this matter we have not advanced beyond his position when he wrote: "Scilicet observatoris est, omnes caussas, quæ errores constantes producere valent, sedulo investigare, et vel amovere, vel saltem earum rationem et magnitudinem summo studio perscrutari, ut effectus in quavis observatione determinata assignari, adeoque hæc ab illo liberari possit, quo pacto res eodem redit, ac si error omnino non affuisset." In addition to eliminating the personal equation, there seems to be, contrary to what might have been expected, little extra advantage in the case of these measures in combining opposite orientations. But that is not really surprising. M. Lœwy has detected more pronounced errors in the measures of the fainter stars, and these have been omitted, so that we are dealing only with a limited range of magnitude. The images possess a more homogeneous character, and the measures are naturally of a higher order of accuracy. The "systematic error" with which M. Lœwy alarmed us must be very small, and further compensations cannot be expected when the errors are almost purely accidental. In practice constant per-

on matters little, for it disappears of course in the
ading the plate constants. It amounts merely to a
acement of the réseau. But it has one inconveni-
doubt arises as to the correctness of the measures of
al star, it is impossible afterwards to revise the
th any certainty unless the personality of the
surer was determined at the time. For instance,
bility applies to the whole of the astrophotographic
red at the Paris Observatory. I regard some of the
bers in the preceding table as due, not to the
to the variability of the personal equation. The
some cases seem to suggest this idea very strongly.
ve already remarked that M. Lœwy's statement that
orientation with a single observer is equivalent to a
bserver is simply an unproved assumption. It is
therefore, to examine the differences between the
asures by A and B of the ordinates of six images of
tars. Now such differences are equally likely to be
n, and the chances of 6, 5, 4, 3 like signs are as
o. As a matter of fact, the numbers of sets of
ith the stated numbers of like signs are 7, 11, 11,
ly, where we should expect about 1 or 2, 8, 20, and
mbers are too small to lay any stress upon them.
ber of sets of differences without a change of sign
larger than it ought to be. Accordingly these cases
worthy of being reproduced in detail, an extra star
which is not strictly qualified to appear. The unit
nces is 0''·0001, and the numbers at the bottom may

course it is possible that M. Lœwy has been unfortunate, and has included among his forty-three stars a case which will only recur once in, say, 10,000 times. If that be so, it is singularly unfortunate that all the observations of this star were not most carefully re-examined. It is curious that M. Lœwy nowhere mentions that immense advantage of the photographic over more direct methods, the possibility of easily referring again to the plate in cases of doubt and revising the measures with special care. But here I cannot think that we have to do with a mere play of chance. It does seem that the observers A and B do systematically differ in their estimation of the centre of the star, and as the difference does not appear merely in the measures of a single image a real cause must perhaps be sought in the nature of the star! This will no doubt appear fanciful,* but it cannot be denied that we have here a singular and apparently inexplicable cause for disquietude. At any rate, it seems clear that the method of multiplied orientations is *not* effective in all cases, though it may be so in the case of the majority of images. If exceptional cases be admitted, we have another reason for saying that no general formula can be constructed for the probable error of a measured coordinate.

15. In conclusion, although M. Lœwy has raised a number of interesting and important questions and has made suggestive contributions towards their solution, the questions have probably not received their final answer, and there seems to be still ample scope for further inquiry. The grounds on which this opinion is based may now be summarised thus:

(*a*) The general method adopted by M. Lœwy is open to objection for two reasons: (1) It is based on assumptions as to the nature of the errors involved the soundness of which is certainly doubtful; (2) the results may be vitiated in a great measure by an unavoidable accumulation of arithmetical error (§§ 3, 4).

(*b*) The observational material discussed is not without defects: (1) It is too restricted in quantity and derived from too small a number of plates; (2) some of the measures were made by inexperienced observers; (3) insufficient care was taken to keep the results of different measurers distinct (§ 9).

(*c*) The contention that personality has no appreciable value cannot in general be maintained. The effect of this equation is proved to be in some cases pronounced (§ 12).

(*d*) The method of changing the orientations in which measures are effected may serve its purpose in reducing the systematic error of measurement in the majority of cases. But it is at least possible that exceptional cases may occur in which the multiplication of orientations will fail to reconcile estimations of the centre of an image on the part of different observers.

* Perhaps a more reasonable cause of the systematic discrepancy may be found in local irregularities in the character of the réseau lines.

s quoted in which such a discrepancy persists even
mages of the same star (§ 14).

y Observatory, Oxford:
1902 May 7.

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*pectroscopic Observations of the Sun-spot group of*
*y 19–June 26.* By the Rev. A. L. Cortie, S.J.,

of Sun-spots of 1901 May 19–June 26, seen during
ations, is noteworthy for several reasons. First, it
roup visible to the unaided eye, occurring at a time
inimum. If one group of small spots seen between
be excepted, the solar surface had been quiescent for
y six months before the appearance of this group,
spots and with very few faculæ, and these faculæ
dinarily faint. The following table deduced from
st series of Sun-spot drawings, supplemented by a
es of direct visual observations by Mr. Hadden, of
J.S.A., shows the quiet state of the solar surface
November and 1901 April before the advent of
p of May–June. The greatest visible disc-area of
m the Stonyhurst drawings was 7·6 on May 22, the
$\frac{1}{000}$ of the visible disc. In the former Sun-spot

solar eclipse of that date. In a previous short account of this Sun-spot group communicated to the *Observatory* (No. 306, June 1901), and before any knowledge of the coincidence in position of the Sun-spot, prominence, and coronal disturbance was attainable, it was stated that "the group was born very close to the E. limb on the invisible side of the Sun, being probably two or three days old when first observed at Stonyhurst on May 20th." In the paper, "On the Types of Sun-spot Disturbances" (*Astrophysical Journal*, vol. xiii. No. 4, May 1901), it is shown how it is possible from the type of a Sun-spot to give a very fair estimate of its age and the date of its birth, even if, as in the present case, it was born on the invisible side of the Sun. It is then most likely—in fact almost certain—that the disturbance in the corona was not only coincident in position with the Sun-spot, but in time also with the date of its birth, and that we witnessed in the corona the effects of the solar disturbance accompanying the birth of the spot.

2. Premonitory signs of this, the only great outburst of the year, had been given for about a month previously to its appearance. On the drawings of April 15, 16, 17, the observer notes that regions north of the equator were disturbed as indicated by the appearance of many groups of evanescent veiled spots. On the 20th the Sun's surface displayed most active and continual changes in the appearance and disappearance of veiled spots. It is to be noted, too, from the table given above that the mean daily number of faculæ gradually increases from January to April, even though they were faint and not very extensive. On April 21 a bright patch of faculæ was both noted by Mr. Hadden and drawn by the Stonyhurst observer on the Sun's E. limb. Its character of brilliancy and compactness was such as accompanies the first appearance of Sun-spots, though on the three following days it was followed by other less brilliant faculæ of more extended area. There is a bare possibility of these faculæ indicating the region of a short-lived spot group that ran its course on the invisible side of the Sun. But the position of the bright patch of April 21 was longitude 168° and N. latitude 8°·5. This is the very position of the spot which subsequently appeared on May 19 at the next rotation, a difference of 8° in longitude between the centre of the faculous and spot groups being accounted for by the extent of the faculæ, and by the difficulty of making extremely accurate measurements when objects are close to the Sun's limb. The coordinates of the spot group on May 20 were longitude 160° and N. latitude 9°. We have here another instance of a facula preceding a Sun-spot to be added to the seven clear cases found on the Stonyhurst drawings, but in this case what is remarkable is that it precedes it by a whole solar rotation. If the barely possible surmise of the faculæ of April 21 and following days, being the remnants of a short-lived storm which had occurred on the invisible hemisphere of the Sun, be admitted, then at least we have a good instance of one spot following another in almost

ition, and thus giving rise to a disturbed area,
in the solar corona of May 18.

the first appearance the spot was visible from
y 31, attaining its greatest area on May 22. From
lay 22 the magnets were absolutely quiet; from
lay 29 there was a series of small disturbances.
a quiet day, followed by a small disturbance on
at during its first passage across the visible disc,
t displayed great activity and attained its maxi-
magnets did not show even a moderate disturb-
ne the spot was visible for a second time from the
th, when it was much reduced in size, being almost
it reached the W. limb on June 26. There were
disturbances of the magnets on the 13th and 21st,
during the month. The other days were days of
ight disturbance. As a set off there were also two
urbances in July when the Sun's surface was almost
escent. The one great solar disturbance of the year,
ch showed itself in a spot visible to the naked eye,
inence, in bright faculæ, and in a unique coronal
was unaccompanied by any considerable magnetic
emingly had but a fortuitous connection with the
oderate disturbances which occurred during its

ectrum of the spot was first observed on May 22
d 3·30 P.M., G.M.T., when the seeing was excellent.
g automatic spectroscope attached to the Perry
inch telescope was used for the observation, the full

| Wave-length. | Element. | Widening. | Intensity. | Remarks. |
|---|---|---|---|---|
| 6261·3 | Ti | 1·0 | 1 | A V line very near. |
| 6265·3 | Fe | 0·4 | 5 | |
| 6267·0 | ... | 1·0 | 0000 | A V line at 6269·0. |
| 6274·8 | ... | 1·0 | 00 | A line just before head of α band, always very widened. |
| 6282·9 | Co | 0·5 | 2 | |
| 6291·2 | Fe | 0·5 | 4 | |
| 6293·0 | V | 0·5 | 000 | |
| 6296·2 | A(O) | 0·5 | 3 | Widening perhaps due to a V line at 6296·6. |
| 6306·0 | O | 1·0 | 2 | Some other lines in the α band were somewhat widened or darkened, but this pair was quite conspicuous, especially the more refrangible line. |
| 6307·0 | O | 1·0 | 2 | |
| 6311·7 | Fe | 0·5 | 1 | |
| 6322·9 | Fe | 0·5 | 4 | |
| 6330·3 | Cr | 0·5 | 1 | A Fe line very close. |
| 6344·4 | Fe | 0·5 | 4 | |
| 6355·2 | Fe | 0·5 | 4 | |
| 6358·9 | Fe | 0·5 | 6 | |
| 6393·8 | Fe | 0·5 | 7 | A close double. |
| 6400·2 | Fe | 0·5 | 8 | „ „ „ |
| 6405·9 | ... | 0·8 | 00 | |
| 6408·2 | Fe | 0·5 | 5 | |
| 6411·8 | Fe | 0·5 | 7 | |
| 6415·2 | ... | ... | 1 | Obliterated over spot. |
| 6417·1 | Fe? | ... | 1 | „ „ „ |
| 6420·2 | Fe | 0·5 | 4 | |
| 6421·6 | Fe | 0·5 | 7 | |
| 6431·1 | Fe | 0·3 | 5 | |
| 6432·9 | Fe? | 0·8 | 1 | |
| 6436·6 | Fe? | 0·8 | 0 | |
| 6439·3 | Ca | 0·5 | 8 | |
| 6450·0 | Ca | 0 5 | 6 | |
| 6455·8 | Ca | 0·8 | 2 | |
| 6456·6 | ... | 0 | 3 | |
| 6462·8 | Ca | 0·5 | 5 | |
| 6463·0 | Fe | | 3 | |
| 6469·4 | ... | 0·5 | 2 | Also darkened in spot. |
| 6471·9 | Ca | 0·5 | 5 | „ „ „ |
| 6475·8 | ... | 0·8 | 2 | „ „ „ |
| 6494·0 | Ca | 0·5 | 6 | |

| Widening. | Intensity. | Remarks. |
|---|---|---|
| 0·5 | 8 | |
| 0·8 | 4 | |
| 0·4 | 6 | |
| 0 | 40 | |

ification of the lines during the observations was
ns of Higgs's Photographic Atlas of the Normal
m. The wave-lengths, elements, and intensities are
Rowland's Preliminary Table of Solar Spectrum
. The widening of the lines is estimated as far as
ms of the normal width of the line. The observa-
22 were revised on May 23 and 24, employing the
rders of a Rutherfurd grating. The same lines were
: most widened line between D and *h* seemed to
e to titanium.

ing table gives a comparison between the average
l average intensity of the lines of the various
rved. In Rowland's table the intensities of the
oned from 1, a line just clearly visible on the map,
H and K. Faint lines below intensity 1 are
rder of faintness from 0 to 0000. In taking an
intensities of the lines of any one element observed,
r the sake of comparison have been reckoned as

| | Number of Lines Observed. | Mean Widening. | Mean Intensity. |
|---|---|---|---|

widening and average intensity as is found by Mr. Evershed (*Memoirs R.A.S.* Appendix II. vol. liv. 1901, p. [91]) between intensity in the "flash" spectrum and intensity in the solar spectrum. Vanadium and titanium are also elements the lines of which are strong in the flash but comparatively weak in the solar spectrum, and the lines of these elements are also, as has been stated before (*Monthly Notices, R.A.S.* vol. li. No. 2, December 1890, p. 77, and vol. lviii. No. 7, May 1898), very much widened in all spots whether of the maximum or minimum epoch. It would seem to follow that the level of Sun-spots is the level of the upper more extensively diffused portion of the stratum of gas which gives the flash spectrum in eclipses. The following is a summary of the chief results which follow from the detailed study of this Sun-spot group :—

1. That the disturbed area of the solar corona of 1901 May 18 marked the time of the actual outburst of the spots.

2. The outburst occurred in a region which had been disturbed for at least a whole rotation of the Sun before the birth of the spots.

3. That in this case of the only great Sun-spot of an otherwise absolutely quiet year there is no connection between the solar storm and magnetic disturbances.

4. That the most widened lines in the spectra of Sun-spots in the red end of the spectrum are always faint lines, chiefly due to vanadium and titanium.

5. That the level of Sun-spots is the level of the upper more diffused gases which give the flash spectrum in total eclipses.

*Stonyhurst College Observatory:*
1902 *May* 4.

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## *The Spectrum of Nova Persei* 1901 *on and after September* 5.

By the Rev. Walter Sidgreaves, S.J.

A reproduction of the spectrum of the Nova, as photographed at Stonyhurst on August 27 and September 5, is given at p. 150 of the December number of the *Monthly Notices*. Since then forty-one photographs have been taken on twenty-eight nights, distributed as in the following list; in which the letters written after the dates have the same significations as in the wave-length tables of the paper referred to: viz. H the Hilger compound prism on the Perry-memorial Equatorial, and T the Thorp objective prism on the 4-inch finder:

September 6, H; 11, T; 14, H, T; 15, H, T; 24, H.
October 4, H, T; 6, H, T; 18, H; 19, H, T; 31, T.
November 1, H; 2, T; 14, T; 22, H, T; 23, H, T; 28, H, T.
December 5, T; 14, H, T; 18, T; 20, H, T.

14, H ; 15, H, T ; 28, H ; 29, T ; 30, H, T ; 31,

10, H ; 12, H.

s plates show the same spectrum in its general
e lines remain very broad, and preserve their relative
This stability of the spectrum is shown in Table I. ;
figures of the first column are brought forward from
r paper for comparison with those of the later dates.
d widths of the lines are given under the letter w ;
ive intensities have been omitted on account of the
between the relations as shown by the two spectro-
yed for the complete spectrum.

arth column, for February 10 and 12, the widths of
ily are quoted. These could be measured without
t the edges of the rest were found to be too ill-
e star was very small, and the trail across the plate
ily too slow for satisfactory definition.

TABLE I.

*Bright line spectrum of Nova Persei*, 1901.

| Nov. 22. | | Dec. 20. | | Feb. 10 & 12. | |
|---|---|---|---|---|---|
| λ | w | λ | w | λ | w |
| 386·8 | 3·2 | 386·8 | 2·6 | 386·8 | 3·0 |
| 396·8 | 3·0 | 396·8 | 2·6 | 396·9 | 2·8 |
| 410·2 | 2·2 | 410·1 | 2·6 | | |
| 434·0 | 2·9 | 434·0 | 2·6 | 434·0 | |
| 436·4 | 3·1 | 436·3 | 2·8 | 436·4 | |

changes, although on account of the failing light of the star, they may be only photographic imperfections. These apparent changes are, in Table II., the relative intensities of the lines 469 and 471 in November and December; and in Table III. the reappearance of lines crossing Hγ.

TABLE II.

*Brighter lines in region* 467–474.

| Aug. 27. λ μμ | Oct. 6 | Nov. 22. | Dec. 20 |
|---|---|---|---|
| 467·3 | 467·5 | 467·3 w | 467·5 |
| 468·6 *c* | 468·8 | 469·1 w | 468·8 ss |
| 470·0 | 470·3 w | 470·3 ? | ? *d* |
| 471·2 ss | 471·3 s | 471·2 w | 471·3 s |
| 472·7 s | 472·9 | 472·7 w | 472·8 |

*Remarks.*— ss = very strong. s = strong. w = weak.

*c* By an error of copy from the original tabulations this line went to the press for the December paper as 468·1 instead of 468·5. The figures in this column are by remeasurements, which have given 470·0 and 472·7 greater than the former measures by 0·2 and 0·3 μμ.

*d* The uncertainty indicated here by the ? is owing to a scratch through the position where the line might be.

TABLE III.

*Brighter lines in region* 432–438.

| | Sept. 5, Oct. 6. λ μμ. | Nov. 22. λ μμ | Dec. 20. λ μμ |
|---|---|---|---|
| | — | 432·7 | 432·7 |
| Hγ | | 433·6 | 433·9 |
| | | 434·4 | |
| | 435·2 | 435·2 | 435·0 |
| 436·3 | 435·9 | 436·1 | |
| | 436·6 | 436·5 | |
| | 437·4 | 437·5 ? | |

The structure of the bands at 386·8 and 396·9 has remained probably quite constant. This structure was given in the December paper as four bright components. At that time there was some doubt about the fourth component, whether it was divided or not. Subsequently greatly enlarged photographs showed the *five* components of the band at 386·8 on September 5, and of both bands on October 4 and 6, and November 22. Again, on December 18, the five components were very clearly marked on the more refracted band, but the companion band at 396·9 was not strong enough to show more than four bright parts, the fourth being relatively broad and very weak. And, similarly, on the plates of January 30 and 31 of this year only three of the components can be seen in the band 386·8, the less

refracted band being much too weak to show details. All through this series of photographs the more refracted of the two bands has been the stronger, and the stronger components of each have been of shorter wave-lengths.

The band at 495·9 on December 20 contains two sharply defined brighter lines near its edges, at 495·1 and 497·0; and the same marking, near the edges, appears in Hβ and in the band 500·7. The photograph of this date was by a remarkably successful exposure in a very clear sky, and compares well with the photograph of August 27. On a careful re-examination of this plate the same structure has been found in the bands 495·9 and 500·7, but only doubtfully in Hβ.

*Stonyhurst College Observatory:*
1902 *May.*

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*Series in the Nebular Spectrum, and in the Bright-Line Spectrum of Nova Persei.* By E. F. J. Love, M.A., Assistant Lecturer and Demonstrator of Natural Philosophy in the University of Melbourne.

## § 1. *Introductory.*

Soon after the spectrum of Nova *Persei* had assumed the nebular type, Lockyer * and Sidgreaves † called attention to the abnormal brightness of three of the lines, compared with that of the "chief" nebular line at λ 5007; Sidgreaves further showed that these lines were characterised, in the Nova spectrum, by identity of structure, while the other lines present had a very different appearance. The wave-lengths of these lines, as estimated by different observers, group round the values λ 4363, λ 3968 and λ 3869.

It seemed to me likely that three lines so closely resembling each other might belong to a series of the general type investigated by Kayser and Runge; I therefore made the attempt to find one, with the results detailed in this paper.

## § 2. *Deduction of Series, and Comparisons with Nebular Lines.*

Since the identification of the lines above-mentioned with nebular lines seems to be beyond dispute, I preferred to use their wave-lengths as measured in nebular spectra, since these have recently been redetermined with great exactness at the Lick Observatory ‡ by Wright, in the course of the observations on

* *Proc. Roy. Soc.* vol. lxix. p. 133; *Monthly Notices*, vol. lxii. App. p. 1.
† *Monthly Notices*, vol. lxii. p. 137.
‡ *Astrophysical Journal*, vol. xiv. p. 267.

Nova *Persei*. The values given by him are 4363·3, 3967·6 and 3868·9; these I find to be included in a series of the form

$$\lambda^{-1} = A + Bn^{-2} - Cn^{-4}$$

where $\lambda^{-1}$ denotes the number of waves per centimetre, A = 25739, B = 43108, C = 1412208, and $n$ has the values 4, 5 and 6 for the three lines. The series relation therefore exists.

Recalling the important fact that the relative intensity of these lines increases as we go towards the violet—exactly the reverse of the usual behaviour of series lines *—it seemed worth while to extend the series, and see if it included other bright nebular lines. Making the calculation I find that $n = 8$ gives the wave-length † of a line observed by Campbell ‡ in the spectrum of the *Orion* nebula, while among higher members of the series I find wave-lengths corresponding to those of a number of lines observed by Huggins § in the spectrum of the trapezium stars and surrounding parts of the *Orion* nebula. Going in the other direction, I find that $n = 3$ gives a wave-length so far down in the extreme red—it corresponds nearly to the middle of the A band in the solar spectrum—as to be extremely difficult to observe in a nebular spectrum, supposing it were present.

The observed and computed values are collected in the following table; it must be noted that—except in the case of the three lines used in deducing the formula—the wave-lengths are only given, by the several investigators, to the nearest tenth-metre.

TABLE.

| $n$ | $\lambda^{-1}$ calcd. (waves per cm.) | $\lambda$ calcd. (tenth-metres.) | $\lambda$ obsd. (tenth-metres.) | Observer. | Notes. |
|---|---|---|---|---|---|
| 3 | 13104 | 7631·3 | ... | ... | Not observed. |
| 4 | 22917 | 4363·3 | 4363·3 | Wright. | Used to deduce the formula. |
| 5 | 25204 | 3967·6 | 3967·6 | ,, | |
| 6 | 25847 | 3868·9 | 3868·9 | ,, | |
| 8 | 26068 | 3836·1 | 3836 | Campbell. | Orion nebula. |
| 10 | 26029 | 3841·9 | 3842 | Huggins. | Orion nebula and trapezium. |
| 13 | 25945 | 3854·3 | 3854 | ,, | ,, ,, ,, |
| If it be legitimate to include $n + \frac{1}{2}$, we obtain two other identifications. | | | | | |
| 11·5 | 25985 | 3848·4 | 3848 | Huggins. | Orion nebula and trapezium. |
| 14·5 | 25912 | 3859·2 | 3859 | ,, | ,, ,, ,, |

* Can the positive sign of the term involving B—which is also the reverse of the usual case—be connected with this fact?

† The minimum possible wave-length for the series; proved by differentiating the equation.

‡ *Astronomy and Astrophysics*, vol. xii. p. 273.

§ *Proc. Roy. Soc.* vol. xlvi. p. 40.

clusion of the last two lines seems legitimate
a symmetry in the values of $n$ which wou
exist; we may then, starting from $n = 8$, arra
o groups, the successive differences being

$$(n = 8)\begin{cases} 2,\ 1,\ 1,\ 1. & \text{First group.} \\ 2,\ 1\tfrac{1}{2},\ 1\tfrac{1}{2},\ 1\tfrac{1}{2}. & \text{Second group.} \end{cases}$$

is inadvisable to carry the table further; if $n$
ease of a unit in its value changes the wave-
$\frac{1}{2}$ tenth-metres; if it exceed 20, we obtain
ht fit almost any line, between λ 3868 and λ 38
ately measured.

3. *Remarks on the Identifications in the Table.*

pbell identifies λ 3836 with $\beta$ (otherwise kno
his seems to me very doubtful. At the time
is everyone believed λ 3968 to be H$\epsilon$, but this i
om Wright's investigation, to be a mistake;
sent, side by side with an "unknown" line,
int, while its unknown companion is bright;
ent at all, should be a still fainter line, but Ca
36 as "bright" in his table. It is true that
nother bright line, at λ 3889, with $\alpha$ (or H$\xi$);
e behaviour of H$\epsilon$ this may be attributed—w

improbable, as neither the lower members of the series, nor λ 3836, are represented in the photograph.*

*University of Melbourne:*
1902 *March* 18.

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*Discovery of Comet Brooks*, 1902. By William R. Brooks, D.Sc.

I have the honour to announce to the Society the discovery of a new comet.

While sweeping the eastern sky on the morning of April 14, I picked up an object in *Pegasus*, which I at once suspected to be a comet. Its position at $21^h\ 5^m$ G.M.T. was approximately R.A. $22^h\ 55^m\ 40^s$, Decl. $+29°\ 12'$. A slight haze and advancing twilight made me hesitate about making a public announcement, but a telegram was sent that morning to Harvard College Observatory of the suspected object.

The following morning was awaited with much interest, which fortunately was clear. The object, it was immediately noticed, had moved from the discovery field and was soon found about three degrees nearer the Sun. Its place on April 15, $21^h$ G.M.T., was R.A. $23^h\ 8^m\ 10$, Decl. $+27°\ 25'$. This gave a daily motion of about $12^m$ east and 2° south.

The comet is a fairly bright telescopic object. It has a very minute stellar nucleus and a short narrow tail.



Comet *Brooks*, 1902.

*Smith Observatory, Geneva, N.Y., U.S.A.*

* The double grouping, exhibited in § 2, may account for the absence of the other radiations from this part of the nebula, and of these from other portions where they are present.





## *trical Measures of Double Stars with the 17½-in. R*

By the Rev. T. E. Espin, M.A.

### I.—*Stars of the Mensuræ Micrometricæ.*

e following list Column 1 gives the number in Σ, C
oximate R.A. and Decl. for 1880, Column 3 the
olumn 4 the distance, Column 5 the number of
6 the magnitudes, Column 7 the date, Column 8

| 880. Decl. | P. | D. | Nights. | Mags. | Date. | |
|---|---|---|---|---|---|---|
| ° ′ | ° | ″ | | | | |
| +54 0 | 37·24 | 5·75 | 3 | ... | 00·99 | |
| +49 19 | 301·20 | 18·25 | 3 | 7·0 8·4 | 99·98 | Note 1. |
| +46 18 | 87·25 | 13·43 | 2 | 7·5 9·5 | 00·60 | Note 2. |
| +50 47 | 150·87 | 1·79 | 2 | ... | 00·38 | AB moti |
| | 124·87 | 34·71 | 2 | = 12·2 | 00·38 | AC. C served |
| | 160·60 | 10·40 | 1 | D 12·7 | 00·87 | CD. |
| +50 53 | 97·35 | 5·05 | 2 | 8·9 9·2 | 99·96 | |
| +57 30 | 148·61 | 1·15 | 3 | 7·0 7·3 | 01·61 | Increase |
| +55 0 | 130·97 | 2·66 | 2 | 6·0 8·0 | 01·88 | |
| +55 1 | 303·81 | 20·73 | 3 | ... | 01·57 | |
| +48 43 | 299·74 | 17·40 | 3 | 4·0 10·0 | 00·36 | ϕ Persei. |

| Σ | R.A. 1880. h m | Decl. ° ′ | P. ° | D. ″ | Nights. | Mags. | | Date. | |
|---|---|---|---|---|---|---|---|---|---|
| 1312 | 9 1·8 | +52 54 | 147·75 | 4·28 | 2 | ... | | 01·10 | |
| 1321 | 6·2 | +53 12 | 65·05 | 18·96 | 2 | 7·1 | 7·5 | 00 08 | Note. |
| | | | 65·55 | 18·77 | 4 | ... | | 01·11 | |
| | | | 65·13 | 18·60 | 3 | ... | | 02 19 | |
| 1341 | 14·3 | +51 7 | 267·44 | 20·69 | 3 | 8·5 | 8·6 | 01·11 | |
| 1366 | 27·4 | +53 51 | 323·80 | 7·88 | 3 | 8·0 | 9·1 | 02·22 | |
| 1368 | 27·8 | +53 51 | 220·44 | 21·12 | 2 | 8·3 | 9·6 | 02·21 | |
| 1402 | 56·8 | +56 4 | 100·60 | 24·90 | 2 | 6·9 | 7 7 | 00 12 | Note. |
| 1427 | 10 14·7 | +44 30 | 216·76 | 9·80 | 2 | 7·0 | 7·2 | 01·20 | |
| 1462 | 35·6 | +51 25 | 172·28 | 7·77 | 2 | 7·2 | 9·5 | 01·65 | |
| 1486 | 47·9 | +52 46 | 101·65 | 28·86 | 2 | ... | | 00·59 | |
| 1495 | 52·4 | +59 35 | 37·77 | 34·10 | 2 | 6·7 | 8·4 | 01·65 | |
| 1543 | 11 22·6 | +40 0 | 2·18 | 5·26 | 2 | 5·0 | 8·8 | 02·25 | Motion. |
| 1553 | 30·0 | +57 48 | 166·42 | 5·00 | 2 | 7·3 | 7·7 | 02·28 | |
| 1572 | 40·6 | +53 58 | 289·15 | 10·20 | 2 | 8·4 | 9·2 | 01·82 | |
| 1608 | 12 5·5 | +54 5 | 223 06 | 11·91 | 2 | 7·5 | 7·7 | 01·35 | |
| 1630 | 13·0 | +57 2 | 168·29 | 2·73 | 2 | 9·0 | 9·2 | 01·82 | |
| 1662 | 30·2 | +57 14 | 234·95 | 19·74 | 2 | ... | | 01·82 | Motion. |
| 1718 | 13 0·2 | +51 37 | 272·06 | 13·21 | 2 | 8·8 | 9·0 | 01·37 | |
| 1758 | 27·9 | +49 45 | 305·37 | 4·47 | 4 | 7·1 | 7·2 | 00·90 | Motion. |
| 1821 | 14 9·2 | +52 21 | 236·78 | 12·74 | 2 | 4·2 | 8·5 | 00·93 | $\kappa$ Boötis. |
| 1843 | 20·2 | +48 22 | 186·63 | 20·35 | 2 | ... | | 01·37 | |
| 1909 | 59·9 | +48 7 | 243·56 | 4·74 | 4 | 7·0 | 7·2 | 01·41 | Motion. |
| 1984 | 15 48·0 | +53 16 | 276·93 | 6·92 | 4 | 6·3 | 8 5 | 01 17 | Motion. |
| 2015 | 16 5·2 | +45 40 | 158·68 | 3·24 | 3 | ... | | 01·05 | AB. |
| | | | 96·84 | 14·21 | 2 | $c=13·2$ | | 01·37 | AC. Not seen before, difficult. |
| 2060 | 26·2 | +47 32 | 255·28 | 5·34 | 2 | 8·7 | 8·8 | 01·45 | |
| 2063 | 28·2 | +45 51 | 195·75 | 16·42 | 3 | 5·5 | 8·1 | 01·08 | |
| 2068 | 30·5 | +47 32 | 255·28 | 5·34 | 2 | 8·7 | 8·8 | 01·45 | |
| 2072 | 32·2 | +47 56 | 180·19 | 5·46 | 3 | 8·6 | 9·1 | 01·16 | Motion. |
| 2078 | 33·4 | +53 10 | 109·54 | 3·48 | 3 | 5·0 | 5·5 | 01·16 | 17 Draconis. |
| | | | 194·52 | 90·55 | 2 | ... | | 00·44 | 16 and 17 Draconis |
| 2082 | 35·5 | +49 10 | 91·11 | 23·74 | 4 | 4·5 | 9·4 | 00·71 | |
| 2130 | 17 2·9 | +54 37 | 326·87 | 2·35 | 3 | 5·0 | 5·2 | 01·16 | $\mu$ Draconis. |
| 2138 | 7·7 | +54 39 | 135·55 | 22·32 | 2 | 8·0 | 8·7 | 00·97 | |
| 2271 | 57·7 | +52 51 | 267·31 | 2·37 | 3 | 6·9 | 7·8 | 00·88 | |
| 2277 | 18 0·0 | +48 28 | 121·45 | 26·91 | 2 | 6·5 | 8·4 | 01·68 | Motion. |
| 2278 | 0·8 | +56 26 | 24·22 | 37·04 | 2 | 7·0 | 7·4 | 00·55 | AB. |
| | | | 147·29 | 6·32 | 2 | | 7·7 | 00·55 | BC. |



*Rev. T. E. Espin, Micrometrical*

| ». Decl. | | P. | D. | Nights. | Mags. | | Date. | |
|---|---|---|---|---|---|---|---|---|
| ° | ′ | ° | ″ | | | | | |
| 58 | 43 | 357·53 | 3·47 | 2 | ... | | 01·16 | Motion. |
| 52 | 16 | 272·23 | 25·42 | 2 | 5·5 | 7·8 | 01·52 | |
| 38 | 12 | 22·70 | 13·56 | 7 | 7·1 | 9·6 | 00·36 | Increase |
| 56 | 35 | 125·41 | 7·53 | 2 | 7·2 | 10·0 | 01·66 | |
| 45 | 37 | 4·08 | 9·55 | 3 | 8·5 | 9·2 | 01·03 | Motion. |
| 44 | 9 | 139·18 | 25·80 | 2 | 7·7 | 9·2 | 01·74 | AB. |
| | | 283·80 | 7·14 | 2 | | 10·0 | 01·74 | BC motio |
| 33 | 27 | 70·90 | 25·59 | 2 | ... | | 01·17 | χ Cygni, |
| 44 | 4 | 160·86 | 9·90 | 2 | ... | | 01·72 | |
| 37 | 47 | 24·62 | 2·42 | 3 | ... | | 01·60 | |
| 47 | 56 | 244·61 | 4·05 | 2 | 8·0 | 8·0 | 01·63 | AB. No |
| | | 300·24 | 11·03 | 3 | | 13·7 | 01·64 | BC. |
| | | 300·15 | 16·72 | 3 | | 12·0 | 01·81 | AD. |
| | | 321·09 | 16·48 | 4 | ... | | 01·73 | BD. |
| | | 164·4 | ... | 1 | ... | | 01·81 | DC. |
| 38 | 13 | 27·40 | 18·63 | 2 | 7·0 | 13·5 | 01·60 | AB, Hall |
| | | 330·92 | 27·87 | 3 | | 8·5 | 01·59 | AC. |
| 43 | 32 | 115·95 | 3·41 | 2 | 8·3 | 8·7 | 01·64 | |
| 52 | 28 | 296·10 | 6·01 | 3 | 7·0 | 7·1 | 01·01 | |
| 56 | 56 | 272·27 | 10·29 | 3 | 8·8 | 9·0 | 01·08 | |
| 57 | 1 | 79·76 | 7·32 | 3 | 7·8 | 9·5 | 01·08 | |
| 55 | 14 | 195·66 | 19·71 | 4 | 6·0 | 6·5 | 00·38 | |

398. De. did not measure this star, and it has been generally neglected. It is too faint to be in the B.D. It lies 33'·*f* 2' *n* of B.D + 57°, 729, which has a very faint comes (too faint to measure satisfactorily with the 17½-in.).

AB P. 325°·46. D 6″·88. Mags. 8·0 13·5 1902·08.

Σ 613. A has a Proper Motion of 0″·047 towards 114°·7.
Σ 619. A change of 16°·7 in angle since Σ.
Σ 1321. A system like 61 Cygni P.M. A 1″·711 towards 249°·1.
B 1″·742 „ 247°·0.

The later observations show that Dunér's formula is correct for position, but makes the distance too large according to recent measures. The following gives closer agreement:

$$\Delta = 19''\cdot721 - 0''\cdot02(t - 1863\cdot0)$$
$$P = 55°\cdot69 + 0°\cdot24(t - 1863\cdot0)$$

The star C was first seen 1901 Jan. 22: it is too faint to measure satisfactorily with the 17½-in. A and B are both strong reddish yellow.

Σ 1402. A has apparent Proper Motion 0″·07 towards 123°·5.

Σ 2619. The star D was first seen by *h*, and has been measured by OΣ and *β*. The star C was detected by OΣ. The comites are difficult to measure with the 17½-in. The position-angle DC was obtained by setting the wire parallel with the stars.

Σ 2708. The star B was detected by Professor Hall, and is called by him 15 mag. It was detected independently with the 17½-in. It is too faint to measure properly, but the measures are sufficient to show that the change is due to the Proper Motion of A. The various measures show that A has a Proper Motion of 0″·26 towards 137°·7 which is in close agreement with the meridian observations.

## II.—*Various Stars.*

(C. A. G. refers to stars found double in the catalogue of the *Astronomische Gesellschaft.*)

| Names. | R.A. 1880 h | m | Decl. ° | ′ | P. ° | D. ″ | Nights. | Mags. | | Date. | Notes. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Espin 40 ... | 0 | 5·1 | +51 | 24 | 72·88 | 3·27 | 2 | 8·7 | 11·7 | 02·03 | AB. |
| | | | | | 316·84 | 23·50 | 2 | | 10·0 | 02·03 | AC. |
| Espin 42 ... | | 16·3 | +52 | 56 | 191·28 | 10·36 | 3 | 8·3 | 9·3 | 01·90 | |
| OΣΣ 7 ... | | 40·6 | +50 | 26 | 76·08 | 50·59 | 2 | 7·5 | 7·7 | 01·97 | |
| Σ 83 rej. ... | | 56 5 | +49 | 40 | 313·50 | 22·09 | 3 | 7·7 | 10·4 | 00·32 | *h* 311°·1. |
| Dawes 8 ... | 1 | 15·3 | +43 | 11 | 140·99 | 2·47 | 2 | 8·5 | 9·0 | 00·98 | No change. |
| Σ 190 rej. | | 50·8 | +40 | 48 | 75·22 | 24·12 | 2 | 8·2 | 9·2 | 00·03 | Separating from PM. |
| *h* 2136 ... | 2 | 21·0 | +53 | 19 | 34·74 | 5·02 | 3 | 8·6 | 9·2 | 00·93 | *h* 37°·1 |
| Holmes ... | 3 | 20·0 | +59 | 30 | 49·94 | 5·40 | 3 | 8·6 | 10·0 | 01·62 | |
| OΣΣ 37 ... | | 30·0 | +44 | 25 | 95·60 | 41·23 | 2 | 6·5 | 6·8 | 01·08 | |
| Espin 55 ... | | 56·2 | +58 | 58 | 261·30 | 9·01 | 2 | 8·1 | 12·5 | 01·98 | A red. |
| Hussey: 12 | 4 | 5·0 | +51 | 31 | 192·29 | 3·66 | 3 | 8·9 | 10·0 | 01·06 | AC found independently. |
| Goodacre ... | | 29·0 | +16 | 16 | 331·25 | 3·73 | 2 | 11·7 | 11·7 | 01·13 | Note. |
| *h* 2241 ... | | 48·9 | +47 | 49 | 263·14 | 11·59 | 3 | 9·0 | 9·1 | 00·66 | |
| C. A. G. ... | | 52·7 | +54 | 39 | 159·99 | 4·21 | 2 | 8·8 | 9·2 | 00·56 | |



*Rev. T. E. Espin, Micrometrical*

| | R.A. 1880 | Decl. | P. | D. | Nights | Mags. | | Date. |
|---|---|---|---|---|---|---|---|---|
| | m | ° ′ | ° | ″ | | | | |
| 6 | 24·9 | +47 52 | 305·88 | 3·58 | 2 | 9·1 | 10·7 | 00·51 |
| | | | 259·40 | 15·81 | 2 | | 13·0 | 00·51 |
| | 38·1 | +43 42 | 24·58 | 45·39 | 4 | | | 00·34 |
| | 50·8 | +57 1 | 174·28 | 6·95 | 2 | 9·1 | 9·2 | 00·09 |
| | | | 3·62 | 15·46 | 2 | | 14 | 00·09 |
| 7 | 29·7 | +57 3 | 66·15 | 12·26 | 2 | 8·7 | 11·7 | 00·09 |
| 8 | 12·6 | +47 47 | 323·10 | 3·80 | 2 | 8·0 | 11·5 | 01·17 |
| | 46·2 | +50 21 | 336·90 | 5·44 | 2 | 8·9 | 9·0 | 01·21 |
| 10 | 8·6 | +58 2 | 318·50 | 8·90 | 2 | 9·0 | 9·2 | 02·29 |
| | 42·0 | +55 55 | 111·11 | 18·96 | 3 | 8·8 | 11·2 | 02·27 |
| 11 | 9·1 | +46 31 | 256·83 | 79·25 | 2 | 6·9 | 7·7 | 02·31 |
| | 32·8 | +52 50 | 157·10 | 13·54 | 2 | 8·6 | 10·8 | 02·29 |
| 12 | 4·3 | +55 35 | 305·81 | 3·64 | 3 | 10·5 | 10·7 | 01·68 |
| | | | 20·87 | 31·25 | 3 | | 8·2 | 01·67 |
| | 34·9 | +40 56 | 3·61 | 6·24 | 2 | 8·1 | 8·8 | 02·31 |
| | 52·2 | +48 7 | 132·15 | 17·77 | 2 | 8·8 | 10·9 | 01·14 |
| 13 | 26·8 | +36 56 | 163·43 | 7·30 | 2 | 9·1 | 9·5 | 01·84 |
| | 29·3 | +39 24 | 23·38 | 33·36 | 3 | 7·5 | 11·3 | 02·31 |
| | 30·8 | +50 16 | 14·09 | 3·30 | 3 | 8·9 | 9·1 | 00·41 |
| | | | 9·19 | 3·17 | 4 | | | 02·30 |
| 14 | 0·8 | +40 33 | 216·23 | 22·33 | 2 | 8·7 | 12·7 | 00·89 |

| Names. | R.A. 1880 h m | Decl. ° ′ | P. ° | D. ″ | Nights. | Mags. | | Date. | Notes. |
|---|---|---|---|---|---|---|---|---|---|
| H*h* 605 ... | 9·4 | + 38 50 | 57·07 | 39·35 | 2 | 7·5 | 7·8 | 00·53 | |
| Aitken 157 | 12·0 | + 37 10 | 142·74 | 2·13 | 3 | 9·0 | 10·0 | 01·58 | Note. |
| Aitken 158 | 12·5 | + 38 58 | 292·53 | 3·50 | 3 | 8·4 | 9·7 | 01·58 | Note. |
| *h* 1506 ... | 20 18·6 | + 35 18 | 202·27 | 9·02 | 2 | 8·3 | 10·5 | 00·66 | AB. *h* 199°·5. |
| | | | 192·55 | 32·67 | 1 | | 10·3 | 00·66 | AC. *h* 191° 1. |
| C. A. G. ... | 41·1 | + 36 20 | 214·25 | 6·30 | 3 | 9·1 | 9·2 | 00·67 | |
| S 786 ... | 21 15·8 | + 52 33 | 300·40 | 47·18 | 3 | 7·6 | 9·0 | 01·01 | |
| *h* 1709 ... | 54·0 | + 56 1 | 316·76 | 9·20 | 2 | 8·9 | 12·0 | 00·66 | *h* 312°·9. |
| H*h* 764 ... | 22 24·1 | + 57 38 | 9·81 | 25·03 | 2 | | | 99·86 | P δ Cephei. |
| C. A. G. ... | 27·6 | + 54 35 | 333·79 | 2·86 | 3 | 8·7 | 9·1 | 01·03 | |
| Dembowski | 29·4 | + 49 46 | 348·42 | 7·88 | 4 | 8·3 | 8·4 | 01·07 | |
| *h* 1849 ... | 23 2·2 | + 45 43 | 347·59 | 47·54 | 2 | 4·7 | 11·0 | 01·82 | 4 Andromedæ. |
| OΣΣ 248 ... | 40·8 | + 50 0 | 339·40 | 23·23 | 1 | 6·5 | 12·0 | 01·83 | AB not seen before. |
| | | | 140·15 | 53·24 | 1 | | 9·0 | 01·83 | AC. |
| Holmes ... | 52·4 | + 57 0 | 75·86 | 18·61 | 2 | 8·0 | 11·0 | 01·92 | |
| Espin 112 | 53·1 | + 52 49 | 221·80 | 1 33 | 4 | 9·0 | 9·2 | 01·99 | |
| OΣΣ 254 ... | 55·0 | + 59 43 | 269·45 | 58 95 | 1 | 7·0 | 8·5 | 00·86 | |

*Notes.*

Goodacre. A little pair 62 sec. *p* α Tauri. Place of α Tauri.

Hussey 224. Found independently, and measured before Hussey's results reached me. Hussey makes the star *p* the double, and my angle differs by 10°. It is a very difficult object.

H*h* 435. I have failed to find any comes in H's place (82°·6).

*h* 540. *h* gives (*h*M*m* 312) 1828·33 30°·18, 14″·19, but in his second catalogue the distance is estimated at 6″.

Aitken 152, 157. 158. These three stars were all detected and measured before Aitken's results reached me.

The following stars I have been unable to find:

| | h | m | ° | ′ | | | |
|---|---|---|---|---|---|---|---|
| *h* 2373 ... | 7 | 15·5 | + 56 | 21 | (1880) | 00 Jan. | 27, Feb. 5. |
| *h* 1222 ... | 12 | 46·8 | + 47 | 26 | ,, | 02 Apr. | 22 |
| H*h* 495 ... | 16 | 1·2 | + 42 | 20 | ,, | 00 June | 8 |
| H*h* 635 ... | 19 | 40·2 | + 37 | 15 | ,, | 00 July | 10 |
| *h* 1481½ ... | 20 | 2·6 | + 32 | 14 | ,, | 00 Sept. | 14 |
| Mayer ... | 21 | 4·0 | + 52 | 12 | ,, | 00 Aug. | 14 |
| H*h* 724 ... | 21 | 12·0 | + 37 | 16 | ,, | 00 ,, | 16 |
| *h* 1773 ... | 22 | 23·4 | + 58 | 17 | ,, | 01 Jan. | 5 |



MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXII. JUNE 13, 1902. No. 8

Dr. J. W. L. GLAISHER, M.A., F.R.S., PRESIDENT, in the Chair.

Henry Bridger Adames, 5 West Street, Chichester, Sussex, was balloted for and duly elected a Fellow of the Society.

The following Candidate was proposed for election as a Fellow of the Society, the name of the proposer from personal knowledge being appended :—

George McKenzie Knight, 27 King Henry's Road, South Hampstead, N.W. (proposed by Walter E. Bealey).

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Seventy-eight presents were announced as having been received since the last meeting, including amongst others :—

G. Bigourdan, Sur la prédiction des occultations des étoiles par la Lune &c. ; G. Bigourdan, Observations des nébuleuses et d'amas stellaires, 2 vols., presented by the author ; A. G. Pingré, Annales célestes du dix-septième siècle, publié par G. Bigourdan; presented by the editor ; Preliminary report of the Dutch expedition to Sumatra for the observation of the total solar eclipse of 1901 May, and report of the Dutch observations, No. 12, presented by the Dutch Eclipse Committee ; Royal Society catalogue of scientific papers, 1800–1883, supplementary volume, presented by the Society ; Solar Physics Observatory, catalogue of 470 of the brighter stars classified according to their chemistry, presented by the Observatory ; W. F. Wislicenus, Astronomischer Jahresbericht, 1901, presented by the author.

*of Groombridge's and Struve's Right Ascensions of Circumpolar Stars.* By W. G. Thackeray.

(*Communicated by the Astronomer Royal.*)

eral was the idea that Groombridge's meridian mark is clear from the positive statements made by Dr. papers "On the Mean Places of forty-eight Circum- *Astronomical Journal*, Nos. 121, 122, and 130. On , vol. vi., he remarks: "Since there can be no doubt ridge's meridian mark was in error about $2\frac{1}{2}''$," and 10, No. 122: "right ascensions which, despite the eal of Piazzi and Groombridge, were referred to eridian marks." The basis of these positive assertions ults of the comparison of Struve's and Argelander's with those of Groombridge made by Fedorenko and which are

lander-Groombridge $= +0^s{\cdot}154 + 0^s{\cdot}188 \tan \delta$
(Fedorenko, p. 8).

ruve-Groombridge $= +0^s{\cdot}036 + 0^s{\cdot}130 \tan \delta$
(Pos. Med. p. cxxviii).

Safford who first (*Monthly Notices*, xlvii. 2, pp. 37–42) ote of doubt on the subject. Dividing the stars truve's and Groombridge's catalogue in four zones he

| | Mean $\Delta\alpha \times \cos\delta$. | P.E. of one Star. | P.E. of a Groombridge Star. |
|---|---|---|---|
| | s | s | s |
| Safford original ... | +0·034 | ±0·093 | ±0·084 |
| „ corrected ... | −0·026 | ±0·063 | ±0·049 |

The probable error of a Groombridge star was obtained by Professor Safford on the supposition that a liberal allowance for errors of observations in the case of Struve would be ±0s·04.

*Zone +86° to +90°.*

| Groomb. No. | Polar Dist. | Secs. of Groomb. Old. | Groomb. New. | New minus Old. | Safford. $\Delta\alpha$ Struve-Groomb. | Safford. $\Delta\alpha$ corrected. | Safford. $\Delta\alpha \cos\delta$ corrected. |
|---|---|---|---|---|---|---|---|
| | ° | s | s | s | s | s | s |
| 144 | 2·0 | 34·75 | 34·97 | +0·22 | − 1·82 | −2·04 | −0·07 |
| 235 | 1·7 | 37·56 | 39·10 | +1·54 | + 0·40 | −1·14 | −0·03 |
| 642 | 4·0 | 6·04 | 6·04 | 0·00 | − 1·14 | −1·14 | −0·08 |
| 1119 | 0·9 | 41·13 | 31·83 | −9·30 | −12·05 | −2·75 | −0·04 |
| 1141 | 2·7 | 58·61 | 52·94 | −5·67 | − 3·73 | +1·94 | +0·09 |
| 1850 | 3·4 | 48·47 | 48·62 | +0·15 | + 1·09 | +0·94 | +0·05 |
| 1871 | 2·5 | 10·11 | 7·63 | −2·48 | − 0·67 | +1·81 | +0·07 |
| 1884 | 1·3 | 48·37 | 42·10 | −6·27 | − 0·93 | +5·34 | +0·12 |
| 2006 | 1·4 | 54·33 | 58·60 | +4·27 | + 3·29 | −0·98 | −0·02 |
| 2065 | 1·5 | 55·71 | 64·64 | +8·93 | +11·80 | +2·87 | +0·07 |
| 2099 | 3·4 | 38·56 | 41·77 | +3·21 | + 3·71 | +0·50 | +0·03 |
| 2210 | 3·3 | 22·65 | 24·07 | +1·42 | + 3·88 | +2·46 | +0·14 |
| 2283 | 2·1 | 17·78 | 16·57 | −1·21 | + 1·63 | +2·84 | +0·10 |
| 2628 | 3·4 | 28·63 | 29·18 | +0·55 | + 0·07 | −0·48 | −0·03 |
| 2667 | 3·1 | 44·40 | 45·81 | +1·41 | + 0·45 | −0·96 | −0·05 |
| 3308 | 1·3 | 41·23 | 43·27 | +2·04 | + 1·83 | −0·21 | 0·00 |
| 3548 | 3·7 | 46·98 | 47·84 | +0·86 | + 0·88 | +0·02 | 0·00 |
| 4101 | 3·7 | 39·78 | 40·44 | +0·66 | − 0·35 | −1·01 | −0·06 |
| | | | *Zone +83° to +86°.* | | | | |
| 67 | 4·7 | 0·19 | 2·60 | +2·41 | + 0·79 | −1·62 | −0·13 |
| 177 | 4·8 | 49·23 | 49·98 | +0·75 | + 0·20 | −0·55 | −0·04 |
| 595 | 5·8 | 30·00 | 31·77 | +1·77 | + 2·49 | +0·72 | +0·07 |
| 750 | 5·0 | 20·22 | 21·31 | +1·09 | + 0·47 | −0·62 | −0·05 |
| 766 | 6·7 | 28·24 | 29·26 | +1·02 | + 0·44 | −0·58 | −0·06 |
| 944 | 4·9 | 18·76 | 18·69 | −0·07 | − 0·83 | −0·76 | −0·06 |
| 956 | 4·8 | 21·23 | 24·37 | +3·14 | + 2·63 | −0·51 | −0·04 |
| 1359 | 5·4 | 50·28 | 46·47 | −3·81 | − 5·56 | −1·75 | −0·16 |
| 1418 | 4·3 | 22·44 | 18·94 | −3·50 | − 5·72 | −2·22 | −0·17 |

. *Thackeray, Comparison of Groombridge's*

*Zone* +83° *to* +86°.

| Secs. of Groomb. Old. | Secs. of Groomb. New. | New minus Old. | Safford. Δα Struve-Groomb. | Safford. Δα corrected. |
|---|---|---|---|---|
| s | s | s | s | s |
| 56·49 | 55·78 | −0·71 | + 0·47 | +1·18 |
| 42·14 | 41·84 | −0·30 | − 0·33 | −0·03 |
| 26·87 | 29·29 | +2·42 | + 2·91 | +0·49 |
| 45·56 | 46·69 | +1·13 | + 1·15 | +0·02 |
| 53·71 | 54·04 | +0·73 | + 1·76 | +1·03 |
| 0·01 | 1·01 | +1·00 | + 1·12 | +0·12 |
| 23·09 | 23·49 | +0·40 | + 1·24 | +0·84 |
| 1·86 | 2·13 | +0·27 | + 1·25 | +0·98 |
| 14·42 | 15·73 | +1·31 | + 1·98 | +0·67 |
| 3·38 | 4·69 | +1·31 | + 0·83 | −0·48 |
| 20·33 | 21·15 | +0·82 | + 0·56 | −0·26 |
| 51·76 | 51·84 | +0·08 | − 2·10 | −2·18 |
| 10·93 | 11·54 | +0·61 | − 0·30 | −0·91 |
| 41·10 | 42·65 | +1·55 | + 0·33 | −1·22 |
| 18·00 | 19·81 | +1·81 | − 0·47 | −2·28 |
| 27·78 | 29·65 | +1·87 | − 0·45 | −2·32 |
| 57·57 | 58·90 | +1·33 | + 0·20 | −1·13 |

Zone +80° to +83°

*Zone* +80° *to* +83°.

| Groomb. No. | Polar Dist. | Secs. of Groomb. Old. | Secs. of Groomb. New. | New minus Old. | Safford. Δα Struve-Groomb. | Safford. Δα corrected. | Safford. Δ cos δ corrected. |
|---|---|---|---|---|---|---|---|
| | ° | s | s | s | s | s | s |
| 1452 | 9·3 | 21·70 | 22·30 | +0·60 | − 0·56 | −1·16 | −0·19 |
| 1463 | 9·3 | 49·55 | 49·71 | +0·16 | − 0·83 | −0·99 | −0·16 |
| 1480 | 8·5 | 52·89 | 54·12 | +1·23 | − 0·08 | −1·31 | −0·19 |
| 1537 | 7·9 | 57·35 | 56·77 | −0·58 | − 1·46 | −0·88 | −0·12 |
| 1643 | 8·6 | 41·61 | 40·60 | −1·01 | − 0·85 | +0·16 | +0·02 |
| 1662 | 8·6 | 0·59 | 0·58 | −0·01 | − 0·36 | −0·35 | −0·05 |
| 1778 | 7·9 | 56·30 | 57·43 | +1·13 | + 1·01 | −0·12 | −0·02 |
| 1782 | 7·9 | 55·13 | 55·33 | +0·20 | − 0·07 | −0·27 | −0·04 |
| 1845 | 8·1 | 3·92 | 4·58 | +0·66 | + 1·86 | +1·20 | +0·18 |
| 1858 | 7·3 | 12·62 | 12·01 | −0·61 | − 0·13 | +0·48 | +0·06 |
| 1909 | 8·7 | 11·13 | 11·93 | +0·80 | + 1·31 | +0·51 | +0·08 |
| 1927 | 8·4 | 35·80 | 36·07 | +0·27 | + 1·34 | +1·07 | +0·16 |
| 1977 | 8·5 | 53·10 | 52·90 | −0·20 | + 0·15 | +0·35 | +0·05 |
| 2037 | 8·7 | 46·07 | 46·30 | +0·23 | + 0·05 | −0·18 | −0·03 |
| 2071 | 8·3 | 8·70 | 8·77 | +0·07 | + 0·80 | +0·73 | +0·11 |
| 2275 | 9·0 | 41·80 | 42·65 | +0·85 | + 1·93 | +1·08 | +0·17 |
| 2276 | 9·0 | 54·46 | 55·27 | +0·81 | + 2·06 | +1·25 | +0·20 |
| 2422 | 7·7 | 51·28 | 52·02 | +0·74 | + 0·29 | −0·45 | −0·06 |
| 2456 | 9·7 | 8·95 | 9·13 | +0·18 | + 0·23 | +0·05 | +0·01 |
| 3268 | 9·2 | 17·30 | 17·52 | +0·22 | + 0·40 | +0·18 | +0·03 |
| 3276 | 9·2 | 36·30 | 37·02 | +0·72 | + 0·43 | −0·29 | −0·05 |
| 3277 | 9·6 | 55·19 | 55·65 | +0·46 | + 0·33 | −0·13 | −0·02 |
| 3370 | 8·2 | 35·07 | 36·14 | +1·07 | + 0·85 | −0·22 | −0·03 |
| 3707 | 8·4 | 25·24 | 25·71 | +0·47 | + 0·23 | −0·24 | −0·04 |
| 3709 | 8·4 | 31·26 | 31·95 | +0·69 | + 0·79 | +0·10 | +0·01 |
| 3887 | 9·6 | 46·32 | 47·37 | +1·05 | − 0·10 | −1·15 | −0·19 |
| 3928 | 7·8 | 52·99 | 54·19 | +1·20 | − 0·30 | −1·50 | −0·20 |
| | | | | *Zone* +70° *to* +80°. | | | |
| 616 | 13·0 | 40·30 | 41·36 | +1·06 | + 0·53 | −0·53 | −0·11 |
| 919 | 11·0 | 29·89 | 30·98 | +1·09 | + 0·71 | −0·38 | −0·07 |
| 966 | 15·1 | 23·25 | 24·24 | +0·99 | + 0·69 | −0·30 | −0·08 |
| 1217 | 12·8 | 9·94 | 10·97 | +1·03 | + 0·63 | −0·40 | −0·09 |
| 1562 | 10·0 | 4·31 | 4·31 | 0·00 | − 0·71 | −0·71 | −0·12 |
| 1650 | 13·3 | 33·02 | 35·18 | +2·16 | + 0·98 | −1·18 | −0·26 |
| [illegible]39 | 11·4 | 6·87 | 7·57 | +0·70 | + 0·58 | −0·12 | −0·02 |

Zone +70° to +80°.

| Secs. of Groomb. | | | Bessel. | | |
|---|---|---|---|---|---|
| Old. | New. | New minus Old. | Δα Struve-Groomb. | Δα corrected. | Δ co |
| s | s | s | s | s | |
| 47·11 | 47·06 | −0·05 | + 0·10 | +0·15 | + |
| 4·45 | 4·27 | −0·18 | + 0·21 | +0·39 | + |
| 22·80 | 23·35 | +0·55 | + 0·65 | +0·10 | + |
| 20·17 | 20·43 | +0·26 | − 0·09 | −0·35 | − |
| 6·78 | 7·53 | +0·75 | + 0·55 | −0·20 | − |
| 16·82 | 18·16 | +1·34 | + 1·46 | +0·12 | + |
| 4·97 | 6·33 | +1·06 | + 1·39 | +0·33 | + |
| 23·80 | 24·15 | +0·35 | + 0·28 | −0·07 | − |
| 28·15 | 27·53 | −0·62 | − 0·69 | −0·07 | − |
| 11·45 | 12·25 | +0·80 | + 0·67 | −0·13 | − |
| 20·32 | 20·46 | +0·14 | 0·00 | −0·14 | − |
| 22·04 | 22·10 | +0·06 | − 0·06 | −0·12 | − |
| 17·75 | 12·82 | −4·93 | (− 4·92) | +0·01 | |
| 24·21 | 19·29 | −4·92 | (− 4·98) | −0·06 | − |
| 25·66 | 25·99 | +0·33 | + 0·08 | −0·25 | − |
| 1·14 | 1·72 | +0·58 | + 0·43 | −0·15 | − |
| 3·00 | 3·31 | +0·31 | + 0·43 | +0·12 | + |
| 48·72 | 48·10 | −0·62 | − 1·16 | −0·54 | − |
| 4·55 | 4·17 | +0·62 | + 0·16 | −0·46 | − |

*The Distribution of the Stars of the Cape Photographic Durchmusterung.* By A. M. W. Downing, D.Sc., F.R.S.

The publication of the C.P.D. is of peculiar interest as enabling us, for the first time, to attack the problem of stellar distribution on a sufficiently extended scale by a method which is free from many of the disabilities attaching to the older method of eye observing, although liable to other disabilities which affect the photographic method.

Thus the photographic plate is far more efficient than the eye in registering the stars to the same order of magnitude in the richer portions of the sky as in more sparsely occupied regions. On the other hand, the determination of a homogeneous system of stellar magnitudes by photography is a difficult and delicate operation.

Notwithstanding, therefore, the fact that M. Stratonoff has already published an instructive note on the subject in *Astron. Nachrichten*, No. 3710, I have thought that it would be of interest to astronomers to exhibit the general results of an analysis of the C.P.D. which I have made pending the publication of a further discussion of the registered stellar magnitudes which is expected from the authors, more especially as my work is carried out on somewhat different lines from those adopted by M. Stratonoff. In what follows the magnitudes of the catalogue are adopted throughout.

I have omitted the partial zone $-18°$, so that the stars whose distribution is here discussed all lie between $-19°$ dec. and the South Pole (Equinox 1875·0).

The first, and of course by far the most laborious, part of the work was to count the stars of different magnitudes occurring in each zone. The magnitude-groups adopted were (1) 0 to 6·2, (2) 6·3 to 6·7, (3) 6·8 to 7·2, (4) 7·3 to 7·7, (5) 7·8 to 8·2, (6) 8·3 to 8·7, (7) 8·8 to 9·2, (8) 9·3 to 9·7, (9) 9·8 to 10·2, and (10) 10·3 and fainter. The numbers in the last group were formed by simply taking the differences between the sums of the first nine groups and the total numbers for each zone. The group is relatively too limited in numbers of stars to be of interest to us in the present connection.

In order to avoid the inconvenience of using large numbers I have exhibited the results of the counts as "density," or number of stars in one square degree.

The first table gives the mean density corresponding to each magnitude-group and the ratio ($\rho$), corresponding to one stellar magnitude computed from the expression

$$n \log \rho = \log D_{m+n} - \log D_m$$

where $D_{m+n}$ is the density from magnitude 0 to magnitude $m+n$, and $D_m$ is the similar density to magnitude $m$.

e noted that the total number of square degrees the survey is 13,911·15, and that the aggregate is 32·66. The total number of stars included in 54,381.

TABLE I.

| nge of Mag. | Mean Density. | Ratio. |
|---|---|---|
| 0 to 6·2 | ·067 | |
| 3 „ 6·7 | ·058 | 3·48 |
| 8 „ 7·2 | ·158 | 5·13 |
| 3 „ 7·7 | ·346 | 4·94 |
| 8 „ 8·2 | ·861 | 5·61 |
| 3 „ 8·7 | 1·744 | 4·71 |
| 8 „ 9·2 | 4·619 | 5·90 |
| 3 „ 9·7 | 8·453 | 4·31 |
| 8 „ 10·2 | 12·254 | 3·07 |
| 3 and fainter | 4·102 | |

er reference will be made to the last magnitude-

e remembered that the authors claim that the plete to mag. 9·2 only. The series of ratios given seem to substantiate this view, as there is a decided r the above-mentioned limit is passed.

step in the discussion was to transform the places comprised in the different magnitude-groups to their rdinates in order to investigate their distribution

and similarly for the subsequent numbers given in the magnitude column.

Column VIII. gives the mean densities for the different magnitude-groups, excluding the stars in the equatorial zone of the galaxy, which are used in forming Column V.

TABLE II.

*Galactic Latitude.*

| Magnitude. | I. −90° to −70°. | II. −70° to −50°. | III. −50° to −30°. | IV. −30° to −10°. | V. −10° to +10. | VI. +10° to +30°. | VII. +30° to +43½°. | VIII. Excluding the Galaxy. |
|---|---|---|---|---|---|---|---|---|
| To 6·2 | ·043 | ·053 | ·050 | ·077 | ·101 | ·066 | ·030 | ·059 |
| 6·5 | ·053 | ·062 | ·056 | ·063 | ·068 | ·046 | ·024 | ·056 |
| 7·0 | ·135 | ·125 | ·140 | ·176 | ·180 | ·149 | ·145 | ·153 |
| 7·5 | ·244 | ·268 | ·292 | ·352 | ·487 | ·353 | ·284 | ·312 |
| 8·0 | ·619 | ·634 | ·661 | ·884 | 1·346 | ·887 | ·679 | ·743 |
| 8·5 | ·917 | 1·023 | 1·219 | 1·869 | 3·035 | 1·727 | 1·386 | 1·431 |
| 9·0 | 1·489 | 2·107 | 2·981 | 5·116 | 9·232 | 4·343 | 2·865 | 3·500 |
| 9·5 | 1·618 | 2·592 | 4·249 | 9·464 | 19·512 | 7·995 | 4·689 | 5·771 |
| 10·0 | 2·593 | 3·412 | 5·058 | 11·354 | 29·808 | 15·503 | 6 280 | 7·997 |
| Sums | 7·711 | 10·276 | 14·706 | 29·355 | 63·769 | 31·069 | 16·382 | |
| Sums to Mag. 9·2 | 3·500 | 4·272 | 5·399 | 8·537 | 14·449 | 7·571 | 5·413 | |
| B.D.* | 3·14 | 3·21 | 3·71 | 6·07 | 8·17 | 5·32 | | |

We recognise here the ring of lucid stars lying nearly in the plane of the galaxy to which Gould and others have drawn attention. It will be remarked that the stars in magnitude-groups 6·5 and 7·0 are much more uniformly distributed than are the brighter stars, and that we must come down to magnitude-group 8·0 before we get as great a relative increase in density between the polar and equatorial zones of the galaxy as we find in the group of lucid stars.

The C.P.D. is not sufficiently extended in galactic longitude in this region to enable us to determine from it with accuracy the deviation (if any) of the ring of bright stars from the plane of the galaxy.

In studying the structure of our universe it is important to note the nearly uniform distribution of the stars of medium brightness.

The falling off in relative density after the magnitude 9·2 is passed, to which attention has been already drawn, as shown in Table I., is apparent throughout the zones of galactic latitude; equally in the polar zone (I.), the equatorial zone (V.), and in the mean densities, excluding the equatorial zone (VIII.). This

* Seeliger's discussion of the Bonn *Durchmusterung* (see Newcomb, *The Stars*, page 249).

wever, be taken as evidence of any thinning out of
he fainter magnitudes here considered, but rather
at we have passed the limit of magnitude to which
complete.

ms" show the aggregate densities in the different
tic latitude for the stars down to mag. 10·2.

ns to mag. 9·2" show the same down to the limit of
which the survey is assumed to be complete. The
s fairly comparable with the Bonn *Durchmusterung*,
f which, as deduced by Seeliger, are given in the
ecognise the greater relative aggregation of stars in
rhood of the galaxy which appears in the photo-
mpared with the visual, survey, to which Kapteyn
ttention. Whether this arises from the greater
he photographic plate in the more crowded regions,
greater actinic activity of stars near the galaxy,
et to be an open question. The C.P.D., however,
the B.D. in assigning an ellipsoidal form to our
stars to the magnitude here considered, although
greater ellipticity of the ellipsoid, by reason of the
ive extension towards the plane of the galactic

. gives the ratios of increase for one magnitude (as
e for the corresponding quantities in Table I.) for
tained in the equatorial zone of the galaxy (I.), and
uum of stars, excluding this zone (II.). The latter
parable with the results obtained by Newcomb from
n of the star densities in certain non-galactic regions
the DM. after the application of systematic correc-

The systematic corrections to the photographic magnitudes of the C.P.D. to reduce them to the visual magnitudes of Gould's Zone Catalogue, which are given by Kapteyn (*Annals of the Cape Observatory*, vol. v. p. 32), exhibit a similar discrepancy between the scales of the photographic and visual systems to that which is here disclosed. It will be remembered that Seeliger, in his discussion of the B.D. results, referred to above, found the value of the ratio in question to lie between 3 and 4 for the brighter stars. Seeliger's researches show that the ratio differs in different parts of the sky, and becomes exceptionally large in the galaxy itself, agreeing in this respect with the results for the relative values of the ratios given in columns I. and II. of Table III.

The publication of the authors' further discussion of the system of photographic magnitudes of the C.P.D. will be awaited with interest.

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## *Note on the Principle of the Arithmetic Mean.*

By H. C. Plummer, M.A.

1. In this note it is proposed to make a brief comparative study of certain lines of argument which are connected with the establishment of the arithmetic mean of a series of direct observations of a single quantity as the most plausible value to adopt. It has been suggested (by Encke, for example) that this position has been assigned to the arithmetic mean by experience, and even that the principle has an axiomatic character. This does not seem by any means to be the case. The arithmetic mean has always been, and probably always will be, adopted because it is by far the easiest function of the observations to calculate.* Also, although demonstrations of the principle may be wanting in rigour, its position has not been assailed by a rival more formidable in this respect or more acceptable on general grounds. If it be granted that positive and negative errors are equally likely to the same amount, it is obvious—and the formal remark has been made by Ellis †—that the arithmetic mean coincides with the true value in the limit when the number of observations is infinite. For if $a$ is the true value, $x_1, x_2, \ldots$ the $n$ observed quantities, and $e_1, e_2, \ldots$ the errors, then

$$\Sigma(x-a) = \Sigma e,$$

so that

$$a = \frac{\Sigma x}{n} - \frac{\Sigma e}{n} = \frac{\Sigma x}{n}.$$

* With the exception of the Median, advocated by Edgeworth (*Camb. Phil. Trans.*, 1889, and *Phil. Mag.*, 1887), and by Estienne in his *Etude sur les erreurs d'observation*, Paris, 1890.

† *Camb. Phil. Trans.* vol. viii. p. 205 (1844).

But the axiom assumed cannot be supposed to hold generally. To consider a very simple example, let observations be made of the position of a point relatively to a scale. If the graduations are equidistant, the axiom will probably hold. If the scale is unequally divided, the axiom seems decidedly improbable. A proof of the principle of the arithmetic mean in the general sense seems therefore to be out of the question. It appears more philosophical to regard the hypotheses on which it has been sought to establish the principle not so much in the nature of axioms as of definitions in the simplest form of the properties which the observations must possess if the principle is to hold.

2. Two preliminary hypotheses which call for little remark may be given. The first is

*Hypothesis I.*—The function to be adopted is a symmetrical function of the observed quantities.

This must be admitted *a priori*, and must be allowed to stand *a posteriori* if the observations actually made are considered equally plausible. The second is

*Hypothesis II.*—The function is homogeneous and of the first degree.

This is necessary if the observations are to be allowed the first element of generality. For otherwise the result would not be independent of the unit of measurement.

3. Any function which satisfies these hypotheses, and which becomes identical with the common value of the observed quantities when these coincide, may be called *a* mean value. By the use of Taylor's Theorem De Morgan * expanded such a function in terms of an arbitrarily chosen magnitude and its deviations from the observed quantities. The terms of the first order reduce to the arithmetic mean of the observations, and he thus showed that every mean value consists of the arithmetic mean together with an aggregate of terms with regard to which we have no *a priori* knowledge. Ferrero † has followed the same order of thought, but has replaced the arbitrary magnitude by the arithmetic mean. He then pointed out that the coefficient of terms of the second order in the deviations in general bears a ratio to the reciprocal of $n$, the number of observations, which does not become infinite with $n$. He therefore concluded that every mean value approximates more closely to the arithmetic mean as the number of observations is increased and their accordance is improved.

4. A third hypothesis may now be added to the preceding. This is

*Hypothesis III.*—If all the measures are given any increment $a$, the most probable value of the quantity sought receives the same increment $a$.

In other words, the result is independent of the origin of

* *Camb. Phil. Trans.* vol. x. p. 416 (1864).

† *Esposizione del Metodo dei Minimi Quadrati*, p. 11 (1876).

measurement. If the most probable value be the function $\phi$ of the observed quantities $x_1, x_2, \ldots x_n$ the analytical expression of the third hypothesis is obtained at once by making the increment $a$ infinitesimal in this form :

$$\frac{\partial\phi}{\partial x_1} + \frac{\partial\phi}{\partial x_2} + \cdots + \frac{\partial\phi}{\partial x_n} = 1 \qquad \ldots \qquad \ldots \quad 1)$$

of which the integral is

$$\phi = \frac{1}{n}(x_1 + x_2 + \ldots + x_n) + F(x_2 - x_1, x_3 - x_1, \ldots, x_n - x_1) \quad (2)$$
$$= M + F$$

where M is the arithmetic mean and F is a function of the differences of the observed quantities which satisfies hypotheses I and II. It must be noticed that there is no necessity to suppose that F is a rational and integral function. Otherwise F would vanish by virtue of hypothesis II. This point will be examined further in § 8.

5. The third hypothesis might be replaced by one expressed in a totally different form and yet equivalent to it—

*Hypothesis III* (*a*).—The law of facility of an error $e$ can be expressed by a function of $e$.

Let $\psi(e)$ be the function to which the probability of an error $e$ is proportional. If, then, $z$ is the most probable result, the product

$$\psi(z-x_1)\,\psi(z-x_2)\ldots\psi(z-x_n)$$

is a maximum. Therefore

$$\frac{\psi'(z-x_1)}{\psi(z-x_1)} + \frac{\psi'(z-x_2)}{\psi(z-x_2)} + \cdots + \frac{\psi'(z-x_n)}{\psi(z-x_n)} = 0.$$

Now the form of this equation which $z$ must satisfy shows immediately that $z$ satisfies the conditions of hypothesis III. Hypotheses III and III (*a*) are therefore equivalent, and the latter imposes on $z$ the form assigned to $\phi$ in (2). The geometric mean of the observed quantities, for example, is inconsistent with any law of facility. This has been remarked by Bertrand,* who deduced equation (1) from the fact that the functional determinant of

$$\phi - x_1, \phi - x_2, \ldots, \phi - x_n$$

vanishes. This argument seems rather to obscure the real simplicity of the result.

6. Bertrand † has also pointed out that the adoption of precise and independent definitions of the terms *precision* and *weight* suffices to restrict the form of the facility function. Let

* *Calcul des Probabilités*, p. 182 (1889).
† *Loc. cit.* p. 210.

s for two different series of observations be $\psi_1(e)$ and
he ratios of the precisions be $h$, and the ratio of the
the two series. The definitions of the terms are
ply that the ratios

$$\frac{\psi_1(he)}{\psi_2(e)} \text{ and } \frac{\psi_1(e)^k}{\psi_2(e)}$$

. Accordingly

$$\psi_1(he)=G\,.\,\psi_1(e)^k$$

independent of $e$. The solution of this functional

$$\psi_1(e)=C \quad \exp.(-ae^\mu)$$

$$k=h^\mu,\ G=C^{1-k}$$

$=2$ the solution gives the orthodox law of facility
$=h^2$. But any even values of $\mu$ would be equally
ith definitions of precision and weight based respec-
idea of equal probability of proportional errors in
of observations, and on the idea of the equivalence
re in one system to several identical measures in

ot intended in this note to consider the form of the
ion as such. But with the general form found in
probable value of the quantity sought from a series
ns must make

The solution is

$$y = \alpha^{\frac{1}{3}} + \beta^{\frac{1}{3}},$$

where $\alpha$, $\beta$ are the roots of the quadratic

$$x^2 - \left[\frac{s_3}{s_0} - \frac{3s_1s_2}{s_0^2} + \frac{2s_1^3}{s_0^3}\right]x + \left[\frac{s_1^2}{s_0} - s_2\right]^3 = 0.$$

Hence

$$z = \mathrm{M} + \alpha^{\frac{1}{3}} + \beta^{\frac{1}{3}}$$

is a function which might be considered the most plausible to adopt as the value of the quantity measured, in the sense that it satisfies the hypotheses so far introduced and is not inherently impossible.

8. The function just found, although not an impossible one nor without a certain interest, has not been constructed for its own sake, but in order to prove by an actual example that hypotheses II and III do not suffice to limit the function of the observed quantities to the arithmetic mean. This is in direct contradiction to the conclusion of Ferrero,* who attempted to prove that the principle of the arithmetic mean was a necessary consequence of these postulates. It has already been noticed in § 4 that F cannot possess a rational and integral form. This suggests that there must be some tacit assumption underlying Ferrero's proof. It is introduced by the expansion of the function in terms of the arithmetic mean and its deviations from the observed quantities. The want of rigour in the proof is due to the assumption that the use of Taylor's Theorem is legitimate. Apparently the existence of functions which cannot be expanded by Taylor's Theorem has been ignored.

9. It is therefore necessary to seek another condition which must be satisfied by the most probable value of the observed quantity. The simplest one seems to be

*Hypothesis IV.*—The independent measures must be combined in such a way that an error which may exist in one of the measures, as $x_1$, shall produce the same error in the "value adopted as the most probable" as would be produced by the same error in $x_2$, $x_3$ or $x_n$.

The axiomatic character of this hypothesis does not seem to be obvious, but as an expression of a necessary property of the most probable value it is at least interesting. The condition is at once expressed in analytical form by making the error in $x_1, x_2, \ldots$ or $x_n$ infinitesimal. The equations immediately obtained are

$$\frac{\partial\phi}{\partial x_1} = \frac{\partial\phi}{\partial x_2} = \frac{\partial\phi}{\partial x_3} = \ldots = \frac{\partial\phi}{\partial x_n} \quad \ldots \quad \ldots \quad (3)$$

* *Loc. cit.* p. 40.

ality gives at once

$$\phi = f(x_1 + x_2).$$

$$\frac{\partial\phi}{\partial x_1} = \frac{\partial\phi}{\partial x_2} = \frac{\partial\phi}{\partial(x_1 + x_2)} = \frac{\partial\phi}{\partial x_3},$$

ently

$$\phi = f(x_1 + x_2 + x_3).$$

hus we obtain finally

$$\phi = f(x_1 + x_2 + x_3 + \ldots + x_n)$$
$$= \phi(\mathrm{M}) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots$$

a function of invariable form, that form see
simply by supposing the observed quantit
a single value $a$. For then clearly

$$\phi(a) = a$$

$$\phi = \phi(\mathrm{M}) = \mathrm{M} \quad \ldots \quad \ldots \quad \ldots$$

rinciple of the arithmetic mean follows fro

othesis IV is due to Stone,* in whose concepti
to have possessed an intuitive character. His n
the equation (4) seems needlessly complicate

different points of view. As has been said, Stone attributed to the condition an *a priori* character. On the other hand, it appears from a later note * that Schiaparelli started with the necessary differential equations and then sought to give them as it were a physical interpretation. Thus Schiaparelli's proof appears frankly artificial, and confirms a remark, made earlier in the present note, that it may be wiser to regard the hypotheses as defining the properties which the observations must possess rather than as axioms on which a rigorous proof of the principle of the arithmetic mean can be founded.

12. I cannot conclude this brief note without expressing my indebtedness to that section of Emanuel Czuber's "Theorie der Beobachtungsfehler" which treats of the principle of the arithmetic mean, both for references and for a connected account of the main lines of earlier discussions of the subject.

*University Observatory, Oxford:*
*1902 May 28.*

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*Experimental Reduction of Photographs of Eros for the Determination of the Solar Parallax.* Second Paper: *Combination of Results from Mount Hamilton, Minneapolis and Cambridge.* Arthur R. Hinks, M.A.

1. In a recent paper (*Monthly Notices*, 1901 November, vol. lxii. p. 22) I attempted to develop a somewhat new method of comparing with an ephemeris positions of a planet derived from measures upon photographs. Briefly the method was this: Separate heliocentric ephemerides of the planet and of the Earth are expressed in rectangular coordinates referred to a mean ecliptic and equinox, the unit being naturally the mean distance of the Sun from the Earth. From these two simple ephemerides (which arise in the process of computing the usual apparent place ephemeris) it is comparatively easy to compute the position of the planet upon a "standard" plate of given centre; the only transformation of coordinates which is not a mere addition, viz. the change from axes in and perpendicular to the ecliptic to axes in and perpendicular to the plate, is expressed in terms of direction cosines and performed with considerable ease on an arithmometer. In fact, the method offers the advantage that almost throughout the coordinates are rectangular, the transformations linear, and the numerical operations are consequently such as can be performed much more readily with a calculating machine than with logarithms.

2. For a trial of the method I measured and reduced fifty-two exposures of *Eros* made at Cambridge on 1900 November 9 and

* *Astr. Nachr.* Nr. 2097 (1876).

details of the reductions to standard, and of the sed of comparing with the ephemeris computed for or E. Millosevich, will be found in the first paper. ion here only one point. In order satisfactorily to observations it was necessary to correct the terms varying directly with the time. At the les on two successive nights the differences, com- bserved position of the planet, were not the same. the ephemeris would not represent the motion of so long a period as twenty-four hours, and in that be clearly impossible to determine the parallax by ethod from the results of any number of single ights. Parallactic shift and progressive error of are hopelessly interwoven, and nothing can be e have observations at the same hour angles, and the same parallax factors, on adjacent nights. an the progressive error of the ephemeris be n the parallax and empirically eliminated before the solution of the equations of condition. It is , that this procedure breaks down unless the series s is fairly continuous—which in the winter of y no means the case—and that in general a large ork of any observatory must be excluded from a ssion of the results of that observatory alone.

lty might be overcome by making a preliminary the results from all the co-operating observatories, from a series of corrections to the tabular place of l basing upon these a new ephemeris. This would

sweep. The photographs of *Eros* number so many thousands that we may expect to find a great many cases where the observations may be separated in this way into small groups. The aim of this paper is to apply to two or three such cases the method of reduction which was developed in the previous paper.

3. The publication in the Paris circulars of a detailed statement of what each observatory has achieved makes it very easy to select good examples of pairs of nearly simultaneous observations at stations far apart. I found that at three observatories in the United States—Lick, Minneapolis, and Northfield—they had plates taken very nearly at the same time as some of those of 1900 November 9 and 10 which I was reducing by the diurnal method. A request for early measures of these plates brought from the directors of the three observatories a very kind and ready response. The measurement of the photographs made at Mount Hamilton with the Crossley reflector had been undertaken by the Columbia University Observatory, New York; and at the request of Professor W. W. Campbell Professor J. K. Rees pushed forward the measurement of eight exposures of the planet and of selected comparison stars, and sent me the measures. Professor F. P. Leavenworth measured seven exposures made at the Observatory of the University of Minnesota, and Professor H. C. Wilson, Director of the Goodsell Observatory, replied that the plate I wanted had been spoiled by passing clouds, and was probably not worth measuring, but promised measures of any other plates that might be useful. To all my sincere thanks are due for the kindness with which they undertook to place at my disposal the material for this second experiment.

4. Meanwhile M. Loewy, President of the *Eros* Commission of the Paris International Conference of 1900, had undertaken to superintend the computation of an eight-figure ephemeris of *Eros* based upon the latest orbit of Professor Millosevich. It was to give, as usual, apparent R.A. and Decl. of the planet, but at my request he promised to print also the separate heliocentric ephemerides of the planet and of the Earth, expressed in rectangular coordinates referred to the mean ecliptic and equinox of 1900·0, which arise in the course of computation of the other ephemeris, and which are of the form most convenient for the method I am using. These ephemerides have recently appeared in the ninth *Paris circular*, and I must not fail to acknowledge my obligations to M. Loewy for the kindness with which he has taken much trouble to forward the trial of a plan very different from that which he himself prefers.

5. We must now reproduce briefly the expressions for the computed place of the planet upon our standard plate, whose centre is given.

Take three rectangular axes, with centre of Sun as origin, directed towards the mean equinox for 1900·0, the point in the ecliptic whose longitude is 90°, and the pole of the ecliptic. At an epoch T, when light left it, the coordinates of the planet on

U, V, W ; at the epoch T + ΔT when that light
th the coordinates of the Earth are *f*, *g*, *h*. These
, V, W ; *f*, *g*, *h*, are found by interpolation in
ephemerides referred to above ; and U − *f*, V − *g*,
coordinates of the planet at T as seen from the
rth at T + ΔT.

that we take a new system of rectangular axes
ntre of the Earth, parallel to the two axes of
rdinates on the standard plate and to the normal
d let $l_1$, $m_1$, $n_1$, &c., be the direction cosines of the
espect to the old. Then the coordinates of the
ject to these new axes are

$$= l_1(U-f) + l_2(V-g) + l_3(W-h)$$
$$= m_1(U-f) + m_2(V-g) + m_3(W-h)$$
$$= n_1(U-f) + n_2(V-g) + n_3(W-h)$$

or the moment the parallax terms, the coordinates
the standard plate are $\xi_o = L/N$, $\eta_o = M/N$.
are adopted in the first paper was therefore as
ite for each exposure T, T + ΔT, and the corre-
olation coefficients, and thence the coordinates
*h*.
ce for all the nine direction cosines ; thence for
he values of L, M, N ; and thence $\xi_o$, $\eta_o$.
s involved a good deal of multiplication by direc-

The values of the direction cosines are :—

| | | |
|---|---|---|
| $l_1$ −·48912876 | $m_1$ −·70890040 | $n_1$ +·50814690 |
| $l_2$ +·80015971 | $m_2$ −·13284009 | $n_2$ +·58489137 |
| $l_3$ −·34712745 | $m_3$ +·69268589 | $n_3$ +·63220945 |

Thence we find for each Berlin midnight the values of L, M, N, and thence of $\xi_0$, $\eta_0$.

We have now an ephemeris which gives the standard coordinates on our plate (except for the parallax displacements which have not yet been put in) of the places of the planet at the times light left it as seen from the Earth at successive Berlin midnights when the light arrived. If we now interpolate in this ephemeris for the mean epochs of our exposures, and calculate the parallax displacements exactly as before (*Monthly Notices*, lxii. p. 30) we have what we want, the computed standard coordinates of the planet at the times the light left it, as seen from our position on the Earth at the times the light reached it.

*Plate Ephemeris of Eros for Plate Centre*, $1^h\ 57^m\ 8^s + 54°\ 22'\ 0''$ (1900-0).

| 1900. | $\xi_0$ | $\eta_0$ |
|---|---|---|
| Nov. 7 | +·01472591 | −·00060344 |
| 8 | +·00947016 | ·00030762 |
| 9 | +·00422788 | ·00027106 |
| 10 | −·00098974 | ·00049666 |
| 11 | −·00617220 | ·00098664 |
| 12 | −·01130788 | −·00174276 |

There is here a considerable saving of labour. We save the greater part of the computation of the epoch T and its interpolation coefficients; of the interpolations for the six quantities U, V, W; $f, g, h$; of the long multiplications by direction cosines, and of the subsequent divisions by N; for these operations have to be performed for six epochs only instead of perhaps a hundred. Eventually we have to interpolate for two quantities, standard coordinates instead of App. R.A.'s and Decl.; and the labour of constructing the plate ephemeris to start with is much less than that of turning a large number of R.A.'s and Decls. into standard coordinates, especially when the former can be done on the arithmometer. Finally we are spared the labour of computing and taking out the correction to the planet's place for the aberration of light, which has in the ordinary course been automatically but improperly introduced by the process of reduction (see Mr. Cowell's paper in *The Observatory*, 1900 December, and mine, *Monthly Notices*, lxii. p. 29).

7. The reduction to standard of the Cambridge exposures

in two steps. An exposure near the meridian s selected as a "zero exposure," and all the expo- ries A (guiding on the stars) were first reduced to ix constant formulæ (Turner's), with constants the measures of fourteen comparison stars nearly lanet in magnitude. All were then reduced from rd by the constants derived from measures of ian standard stars on the zero plate.

ent reductions I have taken the mean of all the A reduced to zero as a new zero plate, with the iding systematic errors in the constants of reduc- ich might arise from accidental errors in the old e. We will call this the mean zero plate.

nts of the reduction from mean zero to standard rom the seven stars on the plate which have been great number of observatories as *étoiles de Eros* plates (*Paris circulars* 8 and 9). The ll for two reasons : first, that the Paris list was astrographic plates of 2° square, and a number t outside the edge of my plates, which cover only cond, that two of the Paris stars are not available, is so bright that adjacent images interfere with e other because it is unfortunately the variable h was faint at the time that *Eros* passed near it. hese two stars were especially wanted to give a ation of the scale value in $\xi$ ; and I am not satis- t of the apparent increase of the tabular error of with the time may not be due to erroneous scale

is the more prudent course, and am not at present prepared to admit that the use of the six constants involves any loss of weight or of rigour.

9. The following are the details of the photographs used in the present discussion.

*Lick. Crossley Reflector. Aperture 3 ft.; focal l. 17 ft. 6 in.*

| Plate No. | Epoch of Mid. Exp. | h | m | s | Duration of Exp. s | No. of Comp. Stars. |
|---|---|---|---|---|---|---|
| 461 (1) | G.M.T. Nov. 9 | 15 | 18 | 15 | 10 | 6 |
| (5) | | 15 | 19 | 50 | 20 | 6 |
| 462 (3) | | 15 | 24 | 5 | 10 | 6 |
| 472 (1) | Nov. 10 | 14 | 16 | 15 | 10 | 7 |
| (3) | | 14 | 16 | 57·5 | 15 | 7 |
| 480 (1) | | 14 | 50 | 15 | 10 | 7 |
| (3) | | 14 | 50 | 57·5 | 15 | 7 |

*Minneapolis. Refractor. Aperture 10½ in.; focal l. 11 ft. 3 in.*

| | | h | m | s | m | s | |
|---|---|---|---|---|---|---|---|
| 1 | Nov. 10 | 13 | 52 | 6 | 2 | 0 | 14 |
| 3 | | 14 | 3 | 49 | 3 | 30 | 14 |

*Cambridge. Refractor. Aperture 12½ in.; focal l. 19 ft. 2 in.*

| | | h | m | s | m | |
|---|---|---|---|---|---|---|
| 246 | Nov. 9 | 15 | 36 | 1 | 3 | 14 |
| 247 | | 15 | 39 | 51 | 2 | ,, |
| 250 | | 16 | 35 | 21 | 3 | ,, |
| 251 | | 16 | 38 | 11 | 2 | ,, |
| 274 | Nov. 10 | 12 | 39 | 29 | 3 | ,, |
| 275 | | 12 | 42 | 24 | 2 | ,, |
| 278 | | 13 | 37 | 24 | 3 | ,, |
| 279 | | 13 | 40 | 19 | 2 | ,, |
| 282 | | 14 | 40 | 54 | 3 | ,, |
| 283 | | 14 | 44 | 24 | 2 | ,, |

After a preliminary reduction of the Lick and Minneapolis measures to the scale of the Cambridge plates the equations of condition were formed to reduce each exposure to the Cambridge mean zero plate, the six constants were found for each exposure, and the measures of the planet reduced to Cambridge mean zero, and thence to standard by the constants derived from the reduction of the mean zero plate to standard with the new places of the *étoiles de repère* from the Paris circulars. These standard places of the planet are next expressed in parts of the radius of projection, and thenceforward the unit to be employed

the radius. It has been assumed for the present
t of each plate is the same.
are concerned more with methods than with
ilts, it is unnecessary to print the details of the
reductions.
r is it necessary to follow in detail the steps
m the equations of condition. The tabular places
were interpolated from the "plate ephemeris";
ctors were found as in the previous paper (*Monthly*
xii. p. 30); the tabular places were corrected for
an assumed value of the solar parallax, and com-
e observed places. Finally means were taken of
vations close together, which are then treated as
n.
e correction required to the assumed value of the
$\Delta\xi_0$ and $\Delta\eta_0$ the corrections to the plate ephemeris
ant for the two short periods under discussion, we
ving equations of condition :—

| | | | | | Residuals. |
|---|---|---|---|---|---|
| | $+1{\cdot}56\,\Delta\pi$ | $-1\,\Delta\xi_0$ | $0\,\Delta\eta_0$ | $-90=0$ | $-3$ |
| | $+0{\cdot}86$ | 0 | $-1$ | $+5$ | $+7$ |
| | $+1{\cdot}62$ | $-1$ | 0 | $-80$ | $+7$ |
| | $+1{\cdot}19$ | 0 | $-1$ | $-16$ | $-14$ |
| 5) | $-1{\cdot}68$ | $-1$ | 0 | $-85$ | $-1$ |
| | $-0{\cdot}11$ | 0 | $-1$ | $+5$ | $+6$ |
| | $-1{\cdot}65$ | $-1$ | 0 | $-87$ | $-2$ |

The normal equations derived from these are :—

| | | | | |
|---|---|---|---|---|
| Nov. 9. | $+11{\cdot}43\,\Delta\pi$ | $-0{\cdot}67\,\Delta\xi_0$ | $-1{\cdot}86\,\Delta\eta_0$ | $-\ 70=0$ |
| | $-\ 0{\cdot}67\,\Delta\pi$ | $+3{\cdot}50\,\Delta\xi_0$ | $0{\cdot}00\,\Delta\eta_0$ | $+299=0$ |
| | $-\ 1{\cdot}86\,\Delta\pi$ | $0{\cdot}00\,\Delta\xi_0$ | $+3{\cdot}50\,\Delta\eta_0$ | $+\ 5=0$ |
| Nov. 10. | $+13{\cdot}47\,\Delta\pi$ | $+1{\cdot}62\,\Delta\xi_0$ | $-1{\cdot}26\,\Delta\eta_0$ | $+131=0$ |
| | $+\ 1{\cdot}62\,\Delta\pi$ | $+6{\cdot}00\,\Delta\xi_0$ | $0{\cdot}00\,\Delta\eta_0$ | $+460=0$ |
| | $-\ 1{\cdot}26\,\Delta\pi$ | $0{\cdot}00\,\Delta\xi_0$ | $+6{\cdot}00\,\Delta\eta_0$ | $+180=0$ |

Eliminating successively $\Delta\xi_0$ and $\Delta\eta_0$ from each of these sets we obtain two equations for $\Delta\pi$.

From Nov. 9. $\quad +10{\cdot}31\,\Delta\pi = +10$

Nov. 10. $\quad +12{\cdot}77\,\Delta\pi = -45.$

Assuming that the p.e. of an equation of weight unity is the same on each night we add these together, and find

$$\Delta\pi = -1{\cdot}5 \qquad = -0''{\cdot}031.$$

If we carry out the solutions separately for each day we obtain

| | | | | |
|---|---|---|---|---|
| For November | 9 | $\Delta\xi_0 = -85$ | $\Delta\eta_0 = -\ 1$ | $\Delta\pi = +0{\cdot}97$ |
| | 10 | $\Delta\xi_0 = -76$ | $\Delta\eta_0 = -31$ | $\Delta\pi = -3{\cdot}52$ |

and substituting back in the equations of condition we obtain the residuals given in the last column.

From these we find

P.E. of one equation of weight unity

| | | | |
|---|---|---|---|
| November | 9 | $\pm 5{\cdot}6$ | $= \pm 0''{\cdot}11$ |
| | 10 | $\pm 2{\cdot}4$ | $= \pm 0''{\cdot}05$ |

The great difference between the apparent weights for the two nights is caused almost entirely by the discrepant Cambridge observation in $\eta$ on November 9 (the fourth equation of condition). On the other hand, perhaps the observations of November 10 are unusually accordant. We may take for the present the p.e. of one equation of weight unity, derived from the mean of a pair of exposures, as about $\pm\ 0''{\cdot}07$ ; and it is scarcely worth while to examine minutely the probable errors of the quantities derived from so few equations.

The differences between the corrections to the tabular places on November 9 and 10 come out rather large, and it is not possible with this small amount of material to say how far they are real. But they emphasise the necessity for dividing the equations, as has been done here, into groups derived from observations nearly simultaneous.

rained from giving the assumed value of the parallax
e observations give the above correction, because no
can be served by publishing preliminary results
ut little weight.

mming up the conclusions which may be drawn
o experimental reductions of *Eros* photographs I

the adopted form of ephemeris in rectangular co-
been found convenient, and may be used in future
uctions.

the direct comparison of simultaneous photo-
lear reductions is the most convenient method of
the *Eros* plates. If the same comparison stars
s not required that their meridian places should
n ; if the meridian places of the comparatively
stars are not quite accurate, the resulting parallax
ected ; if the ephemeris needs correction by terms
the time, practically no harm is done. In fact, by
is way we can find the parallax by methods which
l, and do not involve absolute places, except in a
ree. The gain is obvious.

mallness of the probable error of an equation of
satisfactory evidence of the value of photographic
nding the solar parallax. If the results of a larger
t as well as those that have been discussed here,
, if the p.e. of an equation of condition derived
n of two exposures is about $\pm 0''\cdot 07$, we shall not
ss the whole of the existing material to obtain a

many months. Then when the measures are made we might publish or interchange this raw material and proceed to its discussion.

It should be possible thus to settle in two or three years the question whether or not *Eros* is going to give us the same value of the solar parallax as did the three other less happily situated minor planets. That, I take it, is the main point. If it does not, and we have to proceed eventually to the discussion of the whole mass of material, we shall have gained experience and lost no time by concentrating our energies at first upon a few days' plates.

I must add that my sincere thanks are due to the directors of the Lick Observatory, of the Columbia University Observatory, and of the Oxford University Observatory, who have already cordially agreed to enter into this plan.

*Cambridge Observatory:*
*1902 June 9.*

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*Reductions of photographs of Swift's Comet (a 1899), taken at the Cambridge Observatory, with a portrait lens.* By L. N. G. Filon, M.A., B.Sc.

1. In the summer of 1899 I was working at the Cambridge Observatory, and I undertook to help Mr. A. R. Hinks in taking some photographic observations of Swift's Comet *a* 1899, which was visible during May and the beginning of June as a telescopic object.

The plates taken then had perforce to remain unmeasured for a long time, as the present measuring machine of Cambridge Observatory was still in course of construction, and it was nearly eighteen months before it was ready for use. Stress of other work, however, and the fact that the machine was urgently needed at the Observatory for the measurement of the Eros parallax plates prevented my attending at the time to the reduction of these observations.

In February last the machine was available, and the plates capable of measurement were then measured and reduced. The results of the reduction are presented in this paper.

The photographs of the comet were taken with a portrait lens, of about 30 inches focal length and 5 inches aperture, stopped down to work at $f/8$. The portrait lens and its camera, for the loan of which I understand the Observatory was indebted to Professor Turner, were fixed to the tube of the Northumberland Equatorial, which was used as a guiding telescope. The camera was placed at the object-glass end of the telescope. An exposing shutter could be opened and shut from the eye end by pulling a string attached for the purpose.



taken in this way would repa
reduction.

2. Between May 15 and J
taken of the comet, the first
Hinks and the last ten (May
eighteen plates seven were lon
trailing and varying from 15 t
eleven plates two were taker
and were not considered good
a plate taken on June 14, wh
from the Earth and had becor
visible image of the comet aft
was accidentally broken durin
seven plates with measurable im
exposures, varying from one to e

| Plate No. | Date 1899. | | Exposure (a). | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | h | m | s | m | s | h |
| 5 | May | 19 | 15 | 48 | 35 | −50 | 35 | 1 |
| 7 | | 23 | 17 | 34 | 20 | −39 | 20 | 1 |
| 10 | | 26 | 16 | 35 | 55 | −39 | 55 | 1 |
| 11 | | 29 | 18 | 2 | 40 | − 5 | 40 | 1 |
| 14 | | 31 | 16 | 10 | 8 | −14 | 8 | 16 |
| 16 | June | 3 | 18 | 27 | 0 | −32 | 0 | 18 |
| 17 | | 5 | 17 | 38 | 0 | −43 | 0 | 1 |

The times given in the abo
times of beginning and end of
exposures were measured, excepti

3. A very [illegible]

The two plates were cemented face to face with a little shellac varnish at the corners. This arrangement was found to work perfectly, the only effect of the thickness of glass introduced being to decrease the effective distance of the plate from the object-glass. Accordingly the focus had to be altered and the scale-value was somewhat different; the latter, however, can be adjusted in the Cambridge machine, so that no inconvenience arose on this score.

Effects of distortion in passing through the plate of glass were calculated and found to be quite negligible to the order of accuracy required for the measurements; and, indeed, these two plates have given results quite as satisfactory as the others. This would tend to confirm that the errors of the gelatine film, which the réseau was originally intended to obviate, are practically nil.

This seemed worth pointing out, because it may occasionally, for some reason or other, be impossible for an observer to have a réseau. Such photographs need not therefore be rejected for measurement.

4. In making the measures two or one settings were made on each réseau line, according as the latter was faint or distinct; generally two settings were made on a star image and three to seven settings on a comet image, according to the degree of faintness or diffuseness. The measures were repeated with

| Exposure (*d*). | | | | | | Exposure (*e*). | | | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| h | m | s | h | m | s | h | m | s | m | s | |
| 15 | 57 | 5 − | 16 | 1 | 5 | 16 | 1 | 46½ − | 2 | 46½ | Clouds for (*b*); no réseau. |
| | | ... | | | | | | ... | | | Réseau. |
| 17 | 21 | 0 − | | 25 | 0 | | | ... | | | No réseau. |
| 18 | 19 | 7 − | | 25 | 7 | | | ... | | | Réseau. |
| 16 | 31 | 55 − | | 37 | 55 | | | ... | | | Réseau. Images faint, difficult to measure. |
| | | ... | | | | | | ... | | | Réseau. |
| 18 | 3 | 0 − | | 8 | 0 | | | ... | | | Réseau. |

the plate reversed, and the mean of the direct and reversed measures, corrected for run, was taken as the coordinate of image upon the plate.

The settings on any one réseau line and on any one star image were, as a rule, fairly concordant; those on the comet occasionally differed widely.

The divergences of settings in the respective cases of the comet and of a star are illustrated in Table I., taken from the measurements of Plate 14, where the comet images are faint. Only the micrometer head readings are given, as they alone, of course, exhibit differences.

TABLE I.

(*Coordinate y, Pl.* 14.)

| sure (*d*). | Exposure (*c*). | | Exposure (*b*). | | Exposure (*a*). | |
|---|---|---|---|---|---|---|
| Rev. | Dir. | Rev. | Dir. | Rev. | Dir. | Rev. |
| 352 | 578 | 850 | 528 | 902 | 234 | 158 |
| 375 | 585 | 772 | 496 | 938 | 156 | 165 |
| 369 | 570 | 871 | 502 | 925 | 212 | 186 |
| 365 | 547 | 850 | 526 | 920 | 245 | 162 |
| ... | 550 | 850 | 500 | ... | 210 | ... |
| 214 | 200 | 263 | 267 | 288 | 300 | 260 |
| 210 | 200 | 254 | 265 | 282 | 299 | 262 |
| 222 | 297 | 238 | 266 | 170 | 290 | 138 |
| 220 | 302 | 231 | 264 | 170 | 290 | 143 |
| 172 | 250 | 208 | 187 | 268 | 220 | 240 |
| 170 | 251 | 212 | 190 | 265 | 210 | 240 |
| 351 | 378 | 379 | 310 | 322 | 320 | 297 |
| 353 | 372 | 364 | 310 | 325 | 330 | 290 |
| 342 | 208 | 368 | 267 | 295 | 298 | 378 |
| 346 | 212 | 362 | 274 | 292 | 302 | 373 |
| 441 | 310 | 470 | 289 | 460 | 320 | 522 |
| 436 | 310 | 470 | 290 | 452 | 322 | 524 |
| 602 | 335 | 530 | 290 | 580 | 313 | 549 |

TABLE II.

(*Coordinate y, Pl.* 14.)

| | Exposure (*a*). | | Exposure (*b*) | | Exposure (*c*). | | Exposure (*d*). | |
|---|---|---|---|---|---|---|---|---|
| | Dir. | Rev. | Dir. | Rev. | Dir. | Rev. | Dir. | Rev. |
| let | 20·6552 | 20·6588 | 20·3847 | 20·3833 | 20·1903 | 20·1921 | 20·0431 | 20·0393 |
| 1 | 23·6572 | 23·6563 | 23·4236 | 23·4235 | 23·2671 | 23·2663 | 23·1511 | 23·1512 |
| 2 | 20·4742 | 20·4739 | 20·2415 | 20·2414 | 20·0852 | 20·0849 | 19·9685 | 19·9679 |
| 3 | 24·2365 | 24·2363 | 24·0035 | 24·0041 | 23·8476 | 23·8471 | 23·7312 | 23·7310 |
| 4 | 19·8425 | 19·8425 | 19·6107 | 19·6101 | 19·4574 | 19·4552 | 19·3382 | 19·3370 |
| 5 | 20·4538 | 20·4531 | 20·2211 | 20·2216 | 20·0652 | 20·0642 | 19·9486 | 19·9484 |
| 6 | 22·3039 | 22·3042 | 22·0705 | 22·0705 | 21·9148 | 21·9142 | 21·7980 | 21·7971 |
| 7 | 18·8496 | 18·8501 | 18·6172 | 18·6168 | 18·4624 | 18·4619 | 18·3458 | 18·3450 |
| 8 | 17·4391 | 17·4394 | 17·2063 | 17·2057 | 17·0496 | 17·0492 | 16·9334 | 16·9337 |
| 9 | 20·8389 | 20·8397 | 20·6064 | 20·6053 | 20·4515 | 20·4511 | 20·3341 | 20·3331 |
| 10 | 16·9279 | 16·9278 | 16·6950 | 16·6946 | 16·5385 | 16·5385 | 16·4227 | 16·4220 |

On looking at Table II. we see that for the stars there appears to be a systematic error due to orientation of the plate. Out of forty differences (direct–reversed) only seven are negative. Moreover, the mean value of the numerical difference = 5·4 in the last place = 0″·7 about. The value of the same quantity, calculated from the probable error of a setting, is only about 0″·4.

But it does not necessarily follow that all the systematic error will be eliminated by taking means. In other plates the difference (direct–reversed) shows a large predominance of negative values, showing that the systematic error, if such there be, is not constant, but varies slowly with the time. The error will only be eliminated in so far as it remains constant in the interval (frequently 24 hours or more) between the direct and the reversed measures.

The agreement, however, is sufficient to show us that the probable error of a measurement of an actual star image in this case is well under half a second of arc.

For the comet the mean numerical difference (direct–reversed) = 26 in the last place. If the difference were an accidental one of the same kind as that between settings in the same orientation, the value should be 21. There being only four such differences to form the mean in this case, the discrepancy seems hardly significant. Moreover, for the comet the difference (direct–reversed) is as much positive as negative, suggesting that the large amount of this difference for the comet is chiefly made up of accidental errors. The suggestion is confirmed by the examination of the differences for comet images on other plates.

5. The stars on the plate having been identified by means of a tracing from the Bonn Durchmusterung Charts, a certain

g from 6 to 10, were selected, such that the mean
ughly coincided with the position of the comet.
were taken as comparison stars, and their co-
ell as those of the comet, were measured for each

of the plate was obtained by a rough measure-
lue assumed for its R.A. and Decl. for each plate.
ion of the assumed centre was used for the various
ne same plate, this being found amply sufficient.
rison stars were then identified in the Helsingfors,
Bonn Zone Catalogues, and their R.A.'s and
rought up for precession to the epoch 1899·0,

linates $\xi$, $\eta$ upon an ideally correct plate having
entering and an assumed scale value $l$, which was
50 from a first approximate determination, were

came necessary in all the cases where the plate
a réseau, to apply a large orientation correction to
coordinates, because the camera had to be attached
ial in such a way that the edges of the plate, to
s of the réseau are approximately parallel, made
rly 45° with the plane through the polar axis.
tation correction was determined well within a
ting the measured coordinates $x'y'$ of the stars on
and also plotting the calculated coordinates $(\xi, \eta)$
ce of tracing paper. By superposing the two sets
ngle between the axes of $\xi$ and $x'$ could be read

6. The coordinates $x$, $y$ having been obtained for each star and each exposure, the differences

$$\Delta x = \xi - x \qquad \Delta y = \eta - y$$

were written down.

The plate constants were obtained from the solution of the equations of condition by Dyson's approximate method.

It has been shown by Professor Turner (*Monthly Notices*, 1894, vol. liv. p. 489) and by Mr. Hinks ("The Methods of Reduction and Publication of Measures of Celestial Photographs" (*Astronomical Journal*, No. 475)) that this method gives practically as good values of the constants as the least square solution, the labour being much less.

I have accordingly adopted it in the present case. I have also adhered to the use of the six constants for the reduction of a plate. Theoretically, apart from a certain term due to the refraction, we should have

$$a = e,\ b = -d.$$

Sir David Gill urges that the unsymmetrical part of the refraction correction should be first applied and the equations of condition solved for four unknowns. As authorities appear to be divided on this point, it seemed safer, as well as more straightforward, to retain the six constants.

The values of the constants $a$, $b$, $d$, $e$, calculated separately for each of the 25 exposures measured, are as follows :—

TABLE III.

| Plate. | Exposure | Plate Constants. $a$ | $b$ | $d$ | $e$ |
|---|---|---|---|---|---|
| 5 | (*a*) | +·00743 | −·00769 | +·00870 | +·0072 |
| | (*c*) | +·00738 | −·00782 | +·00885 | +·00686 |
| | (*d*) | +·00726 | −·00783 | +·00862 | +·00674 |
| | (*e*) | +·00715 | −·00789 | +·00866 | +·00649 |
| 7 | (*a*) | +·00592 | −·01976 | +·01955 | +·00536 |
| | (*b*) | +·00549 | −·01951 | +·01963 | +·00545 |
| | (*c*) | +·00522 | −·01974 | +·01947 | +·00547 |
| 10 | (*a*) | +·00527 | +·03401 | −·03399 | +·00522 |
| | (*b*) | +·00519 | +·03228 | −·03215 | +·00486 |
| | (*c*) | +·00547 | +·03219 | −·03231 | +·00540 |
| | (*d*) | +·00530 | +·03229 | −·03250 | +·00529 |
| 11 | (*a*) | +·00603 | −·00924 | +·00924 | +·00606 |
| | (*b*) | +·00646 | −·00900 | +·00902 | +·00633 |
| | (*c*) | +·00621 | −·00897 | +·00900 | +·00609 |
| | (*d*) | +·00612 | −·00888 | +·00928 | +·00655 |

| | Plate Constants. | | | |
|---|---|---|---|---|
| | *a* | *b* | *d* | *e* |
| ) | + ·00505 | − ·04563 | + ·04574 | + ·00497 |
| ) | + ·00519 | − ·04569 | + ·04553 | + ·00487 |
| ) | − ·00516 | − ·04562 | + ·04572 | + ·00497 |
| ) | + ·00515 | − ·04550 | + ·04546 | + ·00495 |
| ) | + ·00576 | − ·00524 | + ·00693 | + ·00573 |
| ) | + ·00712 | − ·00636 | + ·00690 | + ·00536 |
| ) | + ·00610 | − ·02339 | + ·02350 | + ·00586 |
| ) | + ·00574 | − ·02312 | + ·02311 | + ·00588 |
| ) | + ·00596 | − ·02305 | + ·02296 | + ·00589 |
| ) | + ·00588 | − ·02313 | + ·02298 | + ·00607 |

e table shows that the effect of the differential small as a rule. The relations $a = e$, $b = -d$ are y of cases approximately satisfied, but it should be e plates were taken near the zenith.

conclusion comes out from these results, and that ate constants are practically the same for all the one plate. The assumed centre and the large tation correction being in each case the same for all , we see that the constants $a$, $b$, $d$, $e$ differ very ss from one exposure to another.

one or two striking differences, such as $b$ and $d$ of npared with the other exposures of 10 and the tween the constants of 16 ($a$) and 16 ($b$). In the probable cause may have been a slight shake which

TABLE IV.

*x-coordinate.*

O – C.

| Exposure. | Star 1 | Star 2 | Star 3 | Star 4 | Star 5 | Star 6 | Star 7 | Star 8 | Star 9 | Star 10 | Probable error deduced |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5*a* | – 5 | – 4 | + 1 | –36 | +23 | + 7 | – 5 | – 4 | +22 | ... | 11·9 |
| 5*e* | 0 | –10 | + 9 | –34 | +15 | + 7 | – 4 | 0 | +24 | ... | 11·4 |
| 7*c* | + 5 | + 6 | – 4 | + 4 | – 9 | – 6 | – 4 | + 7 | ... | ... | 5·6 |
| 10*a* | + 6 | + 6 | – 8 | – 2 | – 2 | – 4 | + 4 | ... | ... | ... | 4·6 |
| 10*b* | +10 | –11 | + 5 | + 3 | – 4 | 0 | – 3 | ... | ... | ... | 5·1 |
| 10*c* | +10 | 0 | –16 | + 4 | + 6 | – 8 | + 5 | ... | ... | ... | 7·0 |
| 10*d* | 0 | – 6 | + 4 | + 1 | + 2 | + 5 | – 5 | ... | ... | ... | 3·3 |
| 11*a* | +11 | –16 | –19 | +16 | – 2 | – 9 | +12 | – 6 | +12 | ... | 11·4 |
| 11*d* | –24 | + 3 | –10 | + 6 | – 6 | + 1 | +24 | 0 | + 6 | ... | 8·9 |
| 14*b* | 0 | + 7 | + 3 | + 6 | –23 | + 7 | + 3 | –17 | + 9 | + 6 | 8·1 |
| 14*d* | –12 | 0 | – 4 | +14 | –16 | + 9 | + 4 | –18 | +12 | +11 | 10·0 |
| 16*a* | –30 | –21 | – 5 | –14 | + 6 | – 6 | + 1 | +43 | +27 | ... | 17·0 |
| 16*b* | +11 | – 5 | – 8 | + 2 | –20 | – 7 | –28 | +50 | + 6 | ... | 15·2 |
| 17*a* | + 6 | + 3 | – 8 | +15 | – 8 | – 7 | ... | ... | ... | ... | 7·8 |

TABLE V.

*y-coordinate.*

O – C.

| Exposure. | Star 1 | Star 2 | Star 3 | Star 4 | Star 5 | Star 6 | Star 7 | Star 8 | Star 9 | Star 10 | Probable error deduced |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5*a* | +13 | – 9 | –19 | – 7 | – 7 | +16 | + 1 | –10 | +20 | ... | 11·3 |
| 5*e* | +11 | – 6 | – 5 | – 6 | 0 | +18 | + 2 | –24 | +11 | ... | 9·2 |
| 7*c* | – 8 | 0 | + 2 | + 5 | + 3 | – 7 | + 2 | + 2 | ... | ... | 3·6 |
| 10*a* | – 3 | – 2 | – 6 | +13 | +10 | +12 | –23 | ... | ... | ... | 9·9 |
| 10*b* | +16 | –19 | –22 | +20 | +26 | + 3 | –24 | ... | ... | ... | 18·6 |
| 10*c* | + 8 | –12 | –14 | +14 | +20 | + 4 | –19 | ... | ... | ... | 13·0 |
| 10*d* | – 1 | – 4 | – 4 | +14 | +10 | + 5 | –21 | ... | ... | ... | 8·4 |
| 11*a* | +16 | + 8 | –35 | –10 | –12 | +16 | +14 | + 5 | – 4 | ... | 13·3 |
| 11*d* | + 9 | +31 | –35 | –17 | – 6 | +26 | +13 | – 2 | –19 | ... | 17·6 |
| 14*b* | –12 | – 8 | +20 | + 1 | + 4 | – 5 | +10 | + 8 | +13 | –33 | 11·4 |
| 14*d* | –16 | – 1 | +25 | – 8 | + 1 | – 2 | – 6 | +15 | +21 | –25 | 12·0 |
| 16*a* | +42 | + 6 | –48 | –26 | –23 | 0 | +23 | 0 | +26 | ... | 21·6 |
| 16*b* | +42 | +10 | –27 | –24 | –32 | – 5 | +14 | – 6 | +30 | ... | 21·1 |
| 17*a* | + 4 | + 2 | – 6 | +10 | – 6 | – 3 | ... | ... | ... | ... | 5·2 |



appears, therefore, that
itself; it may be due to e
proper motion of the star, w
the plate constants cannot, o
the meridian places used. I
probably not be relied upon m
in the computed places, only t
R.A., and the nearest seco
retained.

Accordingly the quantities
by something of the order of ±
·00073 of a réseau interval, or
event, as is shown further, h
estimate.

Excepting in the case of plat
is unsatisfactory, and of one
divergences amount to less tha
like 7 and 17, for which the oc
favourable, the mean divergences
plates these mean divergences are

Probable divergence i

" "

where, not to weight unduly those
have been calculated for severa
probable errors for the exposures
taken as the probable residual for

If we exclude plate 16 the pro

Probable divergence i

"

I have not been able to obtain the probable errors of the plate constants and of the meridian places directly, but their effect may be allowed for theoretically as follows :—

Consider any residual $\Delta x$.

Let $\epsilon_t$ be the error in $\xi$ due to wrong meridian place, so that

$$\xi + \epsilon_t = \text{correct computed coordinate.}$$

Let $\epsilon_x$ be the error of measurement on the plate, so that

$$x + \epsilon_x = \text{true place of the star on the plate.}$$

Hence accurate difference

$$= \Delta x + \epsilon_t - \epsilon_x.$$

This should be *exactly* fitted by a formula of the type

$$(a + \delta a)x + (b + \delta b)y + c + \delta c,$$

$\delta a$, $\delta b$, $\delta c$ being errors of plate constants due to inaccurate meridian places and errors of measurement. Hence

$$\Delta x + \epsilon_t - \epsilon_x = ax + by + c + x\delta a + y\delta b + \delta c.$$

Now let $\epsilon$ be the residual O—C, exhibited in the tables

$$\epsilon = \Delta x - ax - by + c$$
$$\therefore \epsilon + \epsilon_t - \epsilon_x = x\delta a + y\delta b + \delta c$$
$$\therefore \epsilon_t - \epsilon_x = (x\delta a + y\delta b + \delta c - \epsilon).$$

Square and sum for the $n$ stars measured

$$\Sigma(\epsilon_t - \epsilon_x)^2 = (\delta a)^2\Sigma x^2 + (\delta b)^2\Sigma y^2 + n(\delta c)^2 + \Sigma\epsilon^2$$
$$+ 2\delta a\delta b\Sigma xy + 2\delta a\delta c\Sigma x + 2\delta b\delta c\Sigma y$$
$$- 2\delta a\Sigma x\epsilon - 2\delta b\Sigma y\epsilon - 2\delta c\Sigma\epsilon$$

Now if, as has been the case for the present reductions, the comparison stars have been chosen symmetrically about the origin of coordinates $x$, $y$ we have

$$\Sigma xy = 0 \qquad \Sigma x = 0 \qquad \Sigma y = 0$$

or, at all events, these quantities are small compared with $\Sigma x^2$, $\Sigma y^2$, &c.

Further, if the solution for the constants has been by least squares

$$\Sigma x\epsilon = 0 \qquad \Sigma y\epsilon = 0 \qquad \Sigma\epsilon = 0$$

In the present case the solution has been by Dyson's approximate method; but as this gives results practically identical with those of the least square solution, the above equations will be very approximately satisfied.

hen

$$-\epsilon_x)^2 = (\delta a)^2\Sigma x^2 + (\delta b)^2\Sigma y^2 + n(\delta c)^2 + \Sigma\epsilon^2.$$

$\bar{\epsilon}_x$ be the errors of mean square of the calculated

ured places respectively, and let $\bar{\epsilon}$ be the mean-
l for the $n$ stars on any one plate. Then

$$^2 + \epsilon_x^2 = (\delta a)^2\frac{\Sigma x^2}{n} + (\delta b)^2\frac{\Sigma y^2}{n} + (\delta c)^2 + \bar{\epsilon}^2$$

$= 0$, which will be the case if the errors in the
s and the errors of measurement on the plate are

ions of this kind for a number N of similar sets
) and divide by N. Let $\bar{\epsilon}_a$, $\bar{\epsilon}_b$, $\bar{\epsilon}_c$ be the errors of
f $a$, $b$, $c$.

$$\therefore \bar{\epsilon}_a^2 = \frac{\Sigma(\delta a)^2}{N} \quad \bar{\epsilon}_b^2 = \frac{\Sigma(\delta b)^2}{N} \quad \bar{\epsilon}_c^2 = \frac{\Sigma(\delta c)^2}{N}$$

$$+ \bar{\epsilon}_x^2 = \bar{\epsilon}_a^2\frac{\Sigma x^2}{n} + \bar{\epsilon}_b^2\frac{\Sigma y^2}{n} + \bar{\epsilon}_c^2 + \bar{\epsilon}^2.$$

now to find out the values of $\bar{\epsilon}_a$, $\bar{\epsilon}_b$, $\bar{\epsilon}_c$. Consider a
ces $\Delta x'$, which satisfy equations of condition

$$ax + by + c = \Delta x'.$$

at instead of $a$, $b$, $c$ we have determined constants

This gives at once

$$\bar{\epsilon}_a = \frac{\sigma}{\sqrt{\Sigma x^2}} \quad \bar{\epsilon}_b = \frac{\sigma}{\sqrt{\Sigma y^2}} \quad \bar{\epsilon}_c = \frac{\sigma}{\sqrt{n}}.$$

But $\sigma$ is made up of the errors due both to $\xi$ and to $x$,

$$\therefore \sigma^2 = \bar{\epsilon}_t^2 + \bar{\epsilon}_x^2.$$

So that finally

$$\bar{\epsilon}_a = \sqrt{\frac{\bar{\epsilon}_t^2 + \bar{\epsilon}_x^2}{\Sigma x^2}} \quad \bar{\epsilon}_b = \sqrt{\frac{\bar{\epsilon}_t^2 + \bar{\epsilon}_x^2}{\Sigma y^2}} \quad \bar{\epsilon}_c = \sqrt{\frac{\bar{\epsilon}_t^2 + \bar{\epsilon}_x^2}{n}}.$$

Substituting now in our original equation, we obtain

$$\bar{\epsilon}_t^2 + \bar{\epsilon}_x^2 = \left(\bar{\epsilon}_t^2 + \bar{\epsilon}_x^2\right)\frac{3}{n} + \bar{\epsilon}^2$$

or

$$\bar{\epsilon}_x^2 = \frac{\bar{\epsilon}^2}{1 - \frac{3}{n}} - \bar{\epsilon}_t^2$$

and multiplying by $(\cdot 6745)^2$ to reduce the error of mean square to probable error

$$p_x^2 = \frac{p^2}{1 - \frac{3}{n}} - p_t^2$$

where $p_x$, $p$, $p_t$ are now probable errors.

From this equation we can find the probable error $p_t$ of a meridian place, once the mean residual $p$ and the probable error $p_x$ of a measure are known. A similar equation holds for $y$ and $\eta$.

Now we shall almost certainly err on the side of exaggeration if we take for our probable error of a measure that deduced from the (direct-reversed) on p. 565. The p.e. of the difference we have seen is about $0''\cdot 7$. Accordingly the p.e. of a measure is probably less than $\frac{1}{\sqrt{2}} \times 0''\cdot 7 = 0''\cdot 5$.

It must, however, be remembered that $p_x$ includes errors due to (1) bad driving, (2) distortion, (3) tilt of the plate, as well as the error due to actual measurement.

I have no means of estimating the exact amount of these errors in the present case. A rough calculation, however, shows that for the outermost stars, which are 2° from the centre, the error due to a tilt of 2′ or 3′ would only amount to 1 or 2 in the last place. This would hardly be sufficient to affect the probable error to any extent.

The distortion, though a cubic term, may be sensible for the

s. As to the bad driving, its only effect would be
error of actual measurement (which is known), by
scs elongated, unless indeed the driving was very
:h I do not think was the case.
· I believe $p_x = 0''{\cdot}5$ is a fair value to take, but in
dly think $p_x$ could exceed $0''{\cdot}7$.
$= 0''{\cdot}5$ and $p = 1''{\cdot}23$, *i.e.* the mean of the values
late 16 omitted), we find

$$p_t = 1''{\cdot}47.$$

ludes, besides proper motions and actual errors of
ervations, errors due to cutting off decimals of
only in the places taken from the Catalogue, but
ductions. Mr. Dyson tells me that the probable
one Catalogues is certainly not greater than $0''{\cdot}7$.
ıve an error of $1''{\cdot}4$ due to decimal places neglected.
seem an impossible value, seeing errors may have
n the complicated reductions.
now in a position to obtain the probable error of
position of a measured star on the plate whose
e is not known.
se the error is due to—
:tual error of measurement.
ror due to bad plate constants.
s of the meridian places will indirectly affect the
ion through (2).
be the measured coordinates of such a star. We
ow the probable error of the quantities

provided the error of measurement $\delta x'$ is independent of the position of the star on the plate, which, on the face of it, appears likely.

Now if $\frac{\Sigma x'^2}{n'} = k'^2 = \frac{\Sigma y'^2}{n'}$, $k'$ represents the "scatter" of the measured stars about the centre of the plate.

From a number of similar sets we have

$$\epsilon'^2 = \bar{\epsilon}_x^2 + \bar{\epsilon}_a^2 \frac{\Sigma x'^2}{n'} + \bar{\epsilon}_b^2 \frac{\Sigma y'^2}{n'} + \bar{\epsilon}_c^2$$

Now remember that

$$\bar{\epsilon}_a = \frac{\sigma}{\sqrt{\Sigma x^2}} = \frac{\sigma}{\sqrt{n}} \sqrt{\frac{n}{\Sigma x^2}} = \frac{\sigma}{\sqrt{n}} \frac{1}{k}$$

and similarly

$$\bar{\epsilon}_b \quad \dots \quad \dots \quad = \frac{\sigma}{\sqrt{n}} \frac{1}{k}$$

$$\bar{\epsilon}_c \quad \dots \quad \dots \quad = \frac{\sigma}{\sqrt{n}}$$

where $k$ measures the "scatter" of the comparison stars about the centre of the plate. Accordingly

$$\epsilon'^2 = \bar{\epsilon}_x^2 + \frac{\sigma^2}{n}\left(1 + \frac{2k'^2}{k^2}\right)$$

$$= \bar{\epsilon}_x^2 + \frac{1}{n}\left(\bar{\epsilon}_x^2 + \bar{\epsilon}_l^2\right)\left(1 + \frac{2k'^2}{k^2}\right)$$

or in probable errors

$$p'^2 = p_x^2 + \frac{1}{n}(p_x^2 + p_l^2)\left(2\frac{k'^2}{k^2} + 1\right)$$

gives the probable error of a deduced star place.

Two important facts follow at once from the above formula.

(1) The great value of increasing the number $n$ of the comparison stars.

(2) The still greater value of restricting the area over which lie the stars whose places are required to be well inside of the area occupied by the comparison stars, so that $k'/k$ is well under unity.

In our case, taking as before $n = 8$, and supposing the measured stars and the comparison stars to be distributed over the same area, we find, since $k' = k$,

$$p_x = 0''.5 \qquad p_l = 1''.47$$
$$p' = 1''.08$$

or the probable error is about $1''$.

If, as should always be done in practice, the measured star is

a circle of radius about half that of the circle over
ıparison stars are distributed, $k' = \frac{1}{2}k$, and we find

$$p' = 0''{\cdot}83$$

le error of a deduced star place is well under a

) the higher value for $p_x$, namely $0''{\cdot}7$, the calculated
$' = \frac{1}{2}k) = 0''{\cdot}97$, so that the same conclusion holds.
ɔrrections $\Delta x$, $\Delta y$ for the observed positions of the
ı exposure were then calculated. This gave $\xi$ and $\eta$

The R.A.'s and declinations obtained by solving
tions are given in the following table :—

TABLE VI.

*Places of Comet* 1899 *a* (*Swift*).

| ıte. 99. | Camb. S.T. of Middle of Exposure. h m s | R.A. h m s | Decl. ° ′ ″ |
|---|---|---|---|
| y 19 | 15 49 35 | 22 23 44·5 | 45 18 49 |
| | 15 54 48 | 22 23 42·6 | 45 19 16 |
| | 15 59 5 | 22 23 40·6 | 45 19 32 |
| | 16 2 16½ | 22 23 39·2 | 45 19 46 |
| 23 | 17 36 50 | 21 26 20·6 | 51 56 19 |
| | 17 43 50 | 21 26 16·0 | 51 56 27 |
| | 17 50 36 | 21 26 11·0 | 51 56 51 |

The above are the R.A. and declination of the comet, reduced to the epoch 1899·0, and corrected for precession, nutation, and refraction. The aberration correction, however, has to be considered separately. The part of the aberration due to the motion of the Earth has already been implicitly applied, being involved in the plate constants. But in the case of a comet there is another part, due to the motion of the comet.

Accordingly, in order to obtain from the above data the R.A. and Decl. of the comet free from the effects of aberration, the aberration correction for a star must first be applied with its sign *reversed* and the observations then *antedated* in the manner usual for planets and comets.

11. The accuracy of these comet places will not, owing to the difficulty of measuring a diffuse object, which was occasionally so faint that it required an effort to distinguish it, be comparable with the accuracy of determination of star places as given previously.

A rough determination of the probable error can be made by considering that the changes in R.A. and Decl. for the successive exposures on one plate should be proportional to the time elapsed—a condition which is easily seen from the table not to be accurately satisfied.

Taking the difference of the first and last exposures in each case as giving a more correct value of the rate of change, we can calculate the differences between the 1st and 2nd, 2nd and 3rd, 3rd and 4th, these being proportional to the time.

The deviations from these calculated differences will give us a rough measure of the probable error of the difference of two comet places; dividing this by $\sqrt{2}$ we have the probable error of a comet place.

If we take three of the plates which contain four exposures, viz. 11, 14, 17, and treat them in this way, we obtain the following table—

TABLE VII.

| | | Differences of R.A. Obs. | Cal. | Diff. | Differences of Decl. Obs. | Cal. | Diff. | Differences of Time. |
|---|---|---|---|---|---|---|---|---|
| | | s | s | s | ″ | ″ | ″ | m s |
| Pl. 11 | (*b*−*a*) | −5·8 | −5·0 | ·8 | + 6 | + 1 | 5 | 4 35 |
| | (*c*−*b*) | −4·8 | −5·5 | ·7 | −10 | + 1 | 11 | 5 7 |
| | (*d*−*c*) | −8·9 | −9·0 | ·1 | + 8 | + 2 | 6 | 8 15 |
| Pl. 14 | (*b*−*a*) | −8·5 | −9·2 | ·7 | −10 | −14 | 4 | 9 24 |
| | (*c*−*b*) | −6·6 | −6·0 | ·6 | −18 | −10 | 8 | 6 13 |
| | (*d*−*c*) | −7·1 | −7·0 | ·1 | − 7 | −11 | 4 | 7 10 |
| Pl. 17 | (*b*−*a*) | −4·2 | −3·6 | ·6 | −29 | −23 | 6 | 6 0 |
| | (*c*−*b*) | −4·4 | −4·6 | ·2 | −22 | −28 | 6 | 7 30 |
| | (*d*−*c*) | −6·6 | −7·0 | ·4 | −43 | −43 | 0 | 11 30 |

Mean diff. in R.A. $= 0^s\cdot47$
" " Decl. $= 5''\cdot6$
Probable error in R.A. $= 0^s\cdot33$
" " Decl. $= 4''\cdot0$

: probable error in angle in the direction of $\xi$ we
ply $0^s\cdot33$ $(= 5''\cdot0)$ by sin (mean N.P.D. for plates
. sin $35^\circ = \cdot57$.

$$p.e.\text{ in } \xi \text{ in arc} = 2''\cdot9$$
$$p.e.\text{ in } \eta \quad " \quad = 4''\cdot0$$

t therefore that the probable error of any one comet
$5''$.
esults of these reductions show that photographs
ordinary portrait lens are capable, when measured
f giving star places to about $1''$. In the case of
accuracy is less than this, the probable error
$''$. Such an instrument appears therefore to be
r work not requiring a very high degree of precision.
y it appears that in reducing such plates it is
general, to use the same set of plate constants $a$, $b$,
exposures on a plate.
of increasing the number of the comparison stars,
the stars whose place is to be deduced well *inside*
n stars, appears from the consideration of the
s.

If we consider the *differences* of O—C for various exposures, I find the probable error of such a difference for two exposures on one plate to be, both for $x$ and for $y$,

$$p_{so-sc} = 1''\cdot00.$$

Now, if we suppose the various exposures reduced to the mean of the stars as origin, we have an equation of condition

$$ax + by + c = \delta\xi - \delta x + \Delta_1 x,$$

$\Delta_1 x$ being the *correct* difference if there were no errors.

The equations giving the constants are :

$$\begin{aligned} a\Sigma x^2 &= \Sigma x\delta\xi - \Sigma x\delta x + \Sigma x\Delta_1 x \\ b\Sigma y^2 &= \Sigma y\delta\xi - \Sigma y\delta x + \Sigma y\Delta_1 x \\ cn &= \Sigma\ \delta\xi - \Sigma\ \delta x + \Sigma\ \Delta_1 x. \end{aligned}$$

We may note in passing that this shows that the errors $\delta\xi - \delta x$ cannot be perfectly random, but must be correlated with the coordinates if an error in the plate constants $a$, $b$, $c$ is to exist. For a large number of similar sets, however, the distribution of $\delta\xi - \delta x$ is random, although any *individual* set deviates from the random type.

For another exposure the same equations are :

$$\begin{aligned} a'\Sigma x^2 &= \Sigma x\delta\xi - \Sigma x\delta x' + \Sigma x\Delta_1 x \\ b'\Sigma y^2 &= \Sigma y\delta\xi - \Sigma y\delta x' + \Sigma y\Delta_1 x \\ c'n &= \Sigma\ \delta\xi - \Sigma\ \delta x' + \Sigma\Delta_1 x. \end{aligned}$$

Subtract, and we have :

$$\begin{aligned} (a-a')\Sigma x^2 &= -\Sigma x(\delta x - \delta x') \\ (b-b')\Sigma y^2 &= -\Sigma y(\delta x - \delta x') \\ (c-c')\ n &= -\Sigma\ (\delta x - \delta x'). \end{aligned}$$

The $\delta\xi$'s being the same for both exposures.

Now any difference

$$\begin{aligned} &\delta\,(O-C) \\ &= \delta x - \delta x' + (a-a')\,x + (b-b')y + (c-c'). \end{aligned}$$

Square and sum for the $n$ comparison stars :

$$\begin{aligned} &\Sigma\,(\delta O - \delta C)^2 \\ &= \Sigma\,(\delta x - \delta x')^2 + 2(a-a')\,\Sigma x(\delta x - \delta x') \\ &\qquad + 2(b-b')\,\Sigma y(\delta x - \delta x') \\ &\qquad + 2(c-c')\,\Sigma\,(\delta x - \delta x') \\ &\qquad + (a-a')^2\Sigma x^2 \\ &\qquad + (b-b')^2\Sigma y^2 \\ &\qquad + (c-c')^2 n \end{aligned}$$

$$^2 - \frac{1}{\Sigma x^2}[\Sigma x(\delta x - \delta x')]^2 - \frac{1}{\Sigma y^2}[\Sigma y(\delta x - \delta x')]^2$$

$$- \frac{1}{n}[\Sigma(\delta x - \delta x')]^2$$

again for a large number N of similar sets, then it w that $p_{x-x'}$, $p_{\delta x - \delta x}$ being probable errors

$$p^2_{x-x'}\left(1 - \frac{3}{n}\right) = p^2_{\delta x - \delta x}$$

$$p_x^2 = \tfrac{1}{2} p^2_{x-x'} = \tfrac{1}{2} 1''{\cdot}00 \times \tfrac{8}{5} = ''{\cdot}8$$

$\therefore p_x = ''{\cdot}9$ nearly.

's that my previous estimate was too low, and errors driving, &c., must have been more important than

s $p_t = 1''{\cdot}26$.
ie error of a deduced star place ($k' = \frac{1}{2}k$) $p' = 1''{\cdot}12$.
mewhat larger than the previous result. The error ace is accordingly slightly above, instead of slightly nd of arc.
iitude of $p_t$, as stated in the paper, is chiefly to be the accumulated error in the reductions. This the use of an auxiliary angle, which was computed earest second.

the reticle; then it disappears, but as it reaches each wire there is a flash of light and the chronograph key is tapped. For stars near the pole the light does not flash across the line, but lights it up gradually; the star finally comes into view, remains for an instant—hardly more than time enough to tap the key—and then slowly fades away. Some of the theoretical advantages of the new reticle are:—

1st. The probable error of tapping the key upon the flash would be less than upon the bisection of a star with a wire. With an ordinary reticle the eye and the mind of the observer are under a constant strain to determine when a star is bisected, or to estimate when it will be bisected. With the dark reticle the observer looks into a dark eyepiece, sees nothing, and does not try to see anything until the flash comes, when he strikes the key. Except in case of stars much fainter than are ordinarily observed, there is no difficulty in seeing the flash, and there is no strain upon the eye or upon the attention. It would seem, therefore, that the probable error of tapping the chronograph key would be less than in the old method.

2nd. The personal equation would be less for the reasons given above.

3rd. That part of the personal equation depending upon bright field or bright wires would be eliminated, because all stars would be observed with a dark field.

4th. Fainter stars could be observed, because no light would be lost from the bright field or bright wires.

After the observations mentioned in this article had been made it was found that a London firm of instrument makers was advertising in its catalogue a "flashing transit eyepiece" which seemed to be similar to the dark reticle described here. I have not, however, been able to find any record of observations made with it.

In order to test the probable error of tapping the key when the dark reticle was used, the method described in Chauvenet's *Practical Astronomy*, vol. ii. p. 194, was followed. The observations were made with the large almucantar of the Case Observatory.

Let I = the observed interval between two wires for a star of declination $\delta$.

Computed $i$ = I reduced to the angular distance between the same wires.

True $i$ = true angular distance between the same wires.

$r$ = probable error of the angular distance between two wires.

$\epsilon$ = probable error of tapping the key on one wire.

Then $r = \cdot 6745\sqrt{\frac{[vv]}{m-1}}$, and $\epsilon = \cdot 6745\sqrt{\frac{[vv]}{2(m-1)}}$.

46 *Leonis Minoris* observed 1902 March 13 gave the following results:—

| I | Computed $i$ | True $i'$ | V. |
|---|---|---|---|
| s | s | s | |
| 1·84 | 1·34 | 1·38 | −·04 |
| 1·81 | 1·32 | 1·35 | −·03 |
| 1·90 | 1·38 | 1·34 | +·04 |
| 1·90 | 1·38 | 1·36 | +·02 |
| 1·77 | 1·29 | 1·38 | −·09 |
| 1·89 | 1·38 | 1·36 | +·02 |
| 1·77 | 1·29 | 1·34 | −·05 |
| 1·94 | 1·41 | 1·35 | +·06 |

ve stars gave $[vv] = 1{\cdot}6427$, $m = 280$, and $\varepsilon = {}^{s}{\cdot}037$.
two of these stars were time stars for which $\varepsilon = {\cdot}037$;
irteen were north of declination 70° and $\varepsilon = {\cdot}036$.
ve stars observed with the ordinary reticle gave
'wenty-seven of these were time stars, and gave
e remaining eight were north of 70° declination, and
8.

the probable error of observation is concerned, there
lifference between the two reticles. This probable
ubtedly made up of several components, but as the
his investigation was the comparison of the two
not necessary to separate them. No observations
n made to determine difference of personal equation.
advantage of the dark reticle would seem to be in
of *very* faint stars, for they would be observed in the
the other stars, whereas now they are observed with

quite clear. Colour copper, very dark in centre, but bright near edges. Limb easily seen through telescope. No occultations.

*Perth Observatory, W.A.:*
*1902 April 29.*

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*Observations of Jupiter made at Mr. E. Crossley's Observatory, Bermerside, Halifax, during the months of July, August, and September*, 1901. By Joseph Gledhill.

The following observations of the bands, spots, &c. on the surface of *Jupiter* were made with the 9-inch Cooke refractor (photo-visual). Owing to the considerable south declination of the planet and the unsettled weather it was impossible on any occasion to obtain a really fine view of the details of the markings on the disc. The highest power used was 240, but 150 was found to be most generally useful.

For shortness the dark bands and bright zones are designated as follows:—

*a* the S. temperate band.
*b* the S. equatorial belt.
*c* the N. equatorial belt.
*d* the N. temperate band.
*e* the N.N. temperate band.
*f* the S. tropical zone.
*g* the equatorial zone.
*h* the N. tropical zone.
λ is the longitude of the central meridian System II.

The one salient feature of the disc during the whole of the opposition was the dark broad double band just S. of the equator (S. equatorial belt). There was never any bright space distinctly seen between the components of this fine belt; but, as in past years, the separation was best seen a little to the west of the preceding shoulder.

The red spot was not seen, but a faint grey wisp was once or twice glimpsed resting on the highest point of the *f* shoulder and bending south and westwards: this was probably the eastern end of the red spot or a marking connecting the eastern end with the *f* shoulder.

No warm colour and no distinct detail were seen in the equatorial zone; indeed, there seemed to be a great sameness of tint or brightness over the whole disc; no zone was notably brighter than any other away from the polar regions.

The N. component of *b* (S. equatorial belt) was usually darker than the S. one, and had many dark spots on it which projected a little into the bright central zone.

July 3, $10^h$, $\lambda = 290°$. A dark spot on the N. component of *b* central about $11\frac{1}{2}^h$ ($\lambda = 54°$). *a* and *c* faint grey bands. Rough measures: the double dark band *b* 3″·8 in width; the central bright zone *g*, 3″·8 wide; *a* 1″·4; *f* 2″·3; *c* 1″·4; *h* 3″·2.

$9\frac{1}{2}^h$, $\lambda = 336°$. ***a*** as dark or darker than ***c***; ***b***, as rkest band and the broadest; the N. component of ker than the S.; ***c*** faint and narrow; ***d*** well as dark as ***c***; ***e*** faint and broader than ***d***.

$9^h$, $\lambda = 259°$. ***a***, ***c***, ***d*** faint; the western half of than the eastern half. At $10^h$, $\lambda = 295°$: zone ***f*** er than zone ***h***; ***h*** is nearly as wide as ***g***; zone ***h*** est; the N. component of ***b*** is much broken up and n the S. component.

$10^h$, $\lambda = 236°$. A grey cloud or large spot lies on f the great double S. equatorial belt ***b***: it projects tropical zone until it nearly touches the N. edge of rate band ***a***.

$10^h$, $\lambda = 176°$. The N. component of ***b*** is much ***a*** and ***c*** are faint; ***d*** is broader than ***c***; ***e*** (the N. nd) is narrow; a faint band is seen to the S. of ***a***.

$8^h$, $\lambda = 182°$. The dusky cloud or spot on the S. seen.

$8^h$, $\lambda = 353°$. A bright gap or break in the S. com- is seen: it was central about $7^h\ 53^m$. ***a*** is broader ; ***d*** is the faintest band.

About $8^h\ 45^m$ a dark piece of (or dark spot on) the t of ***b*** was central; a similar one precedes it. They ded but rectangular forms. Band ***a*** is nearer to ***b*** ***c***. At $9^h$, $\lambda = 329°$; a bright gap or break in the t of ***b*** was seen: it is close behind the dark spot entral meridian.

$10^h$, $\lambda = 166°$. A dark spot on the N. component central meridian about $10^h\ 18^m$. Bands ***c*** and ***d***

middle of *b* to *c* 6″·8 ; width of *b* 4″·5 : N. edge of *b* to *c* 3″·7 ; *c* to N. pole 18″·3 ; *c* to S. pole 32″·3 ; central zone *g* 4″·5 ; polar diameter 42″·6 [the ephemeris value 40″·9] ; *a* very faint from $7\frac{1}{2}^h$ to $9^h$. A dark spot on *b* (the N. component) was central about $8^h\ 40^m$. About $9^h$ a few measures were made ; middle of *b* to S. pole 18″·4 ; middle of *b* to N. pole 23″·6 ; width of *b* 4″·6 ; S. edge of *d* to N. pole 10″·5 ; N. edge of *d* to N. pole 8″·1 ; width of *d* 2″·4 ; S. pole to *a* 10″·5 ; middle of *b* to *c* 6″·1 ; *c* to *d* 4″·7 ; S. edge of *d* to N. pole 11″·5 ; width of *b* 4″·5 ; S. edge of *b* to S. pole 15″·6 ; N. edge of *b* to S. pole 20″·3 ; width of *b* 4″·7. A dark spot on the N. component of *b* was central about $9^h\ 18^m$ ; another follows it closely. The bright zone *h* is a little wider than bright zone *g*.

August 27, $7^h$, $\lambda = 169°$. *a* is faint ; *d* is broader than *c* ; there is a bright narrow zone N. of band *d*. A dark spot on the N. component of *b* is now near the central meridian. A narrow bright zone lies immediately S. of *a*. The region N. of *c* up to the pole is brighter than the region about the S. pole. The grey spot on *b* above named was central about $8^h\ 22^m$ : it is faint and diffuse ; its length is about 4″, and the height perhaps about the same.

September 4, $8^h$, $\lambda = 327°$. *a* is as well seen as *c* and *d*.

September 5, $7^h$, $\lambda = 81°$. The *f* shoulder is a little W. of the central meridian. *a* is faint ; *c* is narrow but darker than *a* ; *d* is broader and darker than *c*.

September 10, $7^h$, $\lambda = 112°$. *a* faint ; *d* broader than *c*. $7^h\ 10^m$ to $7^h\ 15^m$ one (or two ?) dark spots on band *b* (N. component) very near or on the meridian ; and the *f* shoulder is near the *p* limb.

September 11, $7^h$, $\lambda = 262°$. *a* is fainter than *c* or *d*.

September 15, $8^h$, $\lambda = 179°$. The grey spot on the S. edge of *b* is seen ; probably on the meridian about $8^h\ 15^m$ ; planet low and motion very great.

September 18, $6^h$, $\lambda = 197°$. *a* faint ; *c* broad and well seen ; *d* broad and less dark than *c*. The grey spot on *b* central about $6^h\ 20^m$.

September 20, $8^h$, $\lambda = 209°$. The grey spot on *b* central about $8^h$.

October 17, $5^h$, $\lambda = 193°$. The grey spot on *b* on the central meridian about $5^h$ ? Violent motion ; Sun just set ; *a* faint ; *c* darker ; *d* still darker and broader than *a* or *c*.

Collecting the transits of the grey spot on the S. edge of *b* and lying in and across zone *f* we have :

| 1901. | d | h | m | ° | 1901. | d | h | m | ° |
|---|---|---|---|---|---|---|---|---|---|
| July | 17 | 10 | 15 | 245 | Sept. | 15 | 8 | 15 | 188? |
| Aug. | 15 | 8 | 38 | 225 | | 18 | 6 | 20 | 209? |
| | 20 | 7 | 42 | 223 | | 20 | 8 | 0 | 209? |
| | 22 | 9 | 17 | 221 | Oct. | 17 | 5 | 0 | 193? |
| | 27 | 8 | 22 | 219 | | | | | |

## ɪrvations of the New Star in Perseus made at the Radcliffe Observatory, Oxford.

nicated by Arthur A. Rambaut, M.A., Sc.D., F.R.S., Radcliffe Observer.)

is in continuation of the notes on the same sub- in the *Monthly Notices* for March, April, May, ember 1901.

ɔal fluctuation of brightness has been noticed, but nution at the rate of about 0·01 mag. per diem, as he last paper (*Monthly Notices*, lxii. No. 1), has ed. Accordingly no attempt has been made to ous watch upon the star, and the observations have ɔomparatively long intervals.

continues to become more bluish. In the last pointed out that the star appeared for the most ɛ. From the observers' notes on colour in the ɪt will be seen that a bluish tint has for the most

ɜss of the object, its low altitude, and the increased ɔrobably prevent further observations until the

ng instruments were employed as indicated in the f Table II.

ɛlay 10-inch equatorial, power 90.
2·7-inch finder „ 13.

| Ref. No. | Name of Star. | Adopted Tabular Magnitude. | Authority for Magnitude. |
|---|---|---|---|
| 74 | Arg. Z. +44°, 742 | 7·76 | Harvard Photom. D.M. |
| 75 | +43, 728 | 8·4 | Argelander D.M. |
| 76 | +43, 729 | 8·7 | „ „ |
| 77 | +43, 739 | 9·0 | „ „ |
| 78 | +42, 776 | 7·8 | „ „ |
| 79 | +42, 767 | 9·5 | „ „ |
| 80 | +42, 768 | 8·9 | „ „ |
| 81 | +43, 744 | 8·6 | „ „ |
| 82 | +43, 746 | 9·1 | „ „ |
| 83 | +43, 751 | 9·0 | „ „ |
| 84 | +43, 749 | 9·0 | „ „ |

TABLE II.

*Means of Estimations of Magnitude of Nova Persei.*

| G.M.T. | | | Observer. | Aperture of Telescope. | Reference Stars. | Mean Mag. | Adopted Mag. for the Night. |
|---|---|---|---|---|---|---|---|
| 1901. | h | m | | Inch. | | | |
| Nov. 15 | 7 | 30 | R. | 1·8 | 64, 65 | 7·17 | 7·17 |
| 21 | 8 | 30 | C. | 2·7 | 65, 64, 70, 67 | 7·37 | |
| | 9 | 20 | W. | 2·7 | 65, 64, 54 | 7·21 | 7·24 |
| | 9 | 20 | W. | 10·0 | 65, 64, 58, 62–63 | 7·07 | |
| 28 | 5 | 45 | W. | 2·7 | 65, 64 | 7·25 | |
| | 5 | 45 | W. | 10·0 | 65, 64, 58, 63, 62, 61 | 6·90 | |
| | 5 | 45 | R. | 2·7 | 64, 65 | 7·20 | 7·20 |
| | 7 | 0 | C. | 2·7 | 64, 67, 65, 70 | 7·37 | |
| | 7 | 0 | C. | 10·0 | 65, 70 | 7·28 | |
| Dec. 2 | 8 | 35 | R. | 2·7 | 65, 64 | 7·30 | |
| | 8 | 55 | R. | 10·0 | 65, 64 | 7·40 | 7·35 |
| 4 | 8 | 30 | W. | 2·7 | 65, 64, 58, 70 | 7·24 | |
| | 8 | 35 | W. | 10·0 | 65, 64, 54, 70 | 7·16 | |
| | 8 | 45 | R. | 2·7 | 65, 64, 58, 70, 67 | 7·42 | 7·32 |
| | 8 | 50 | R. | 10·0 | 65, 64 | 7·50 | |
| 1902. | | | | | | | |
| Jan. 4 | 9 | 45 | C. | 10·0 | 65, 71, 72, 70 | 7·52 | 7·52 |
| 28 | 10 | 8 | C. | 10·0 | 71, 72, 73, 74 | 7·97 | 7·97 |

| Observer. | Aperture of Telescope. Inch. | Reference Stars. | Mean Mag. | Adopted Mag for the Night. |
|---|---|---|---|---|
| R. | 2·7 | 71, 75, 73, 72, 77 | 8·08 | 8·27 |
| R. | 10·0 | 71, 76, 73, 72, 77 | 8·46 | |
| R. | 10·0 | 77, 72, 73, 71, 78, 76 80, 79, 81, 82, 83 | 8·66 | 8·66 |
| C. | 10·0 | 77, 81, 82, 83, 84, 76 | 8·80 | 8·80 |

*servers' Notes on the Estimation of Magnitude.*

ova, by averted vision, appeared much brighter than other
of the same magnitude. This peculiarity caused a difficulty
stimating magnitudes. It was not easy to get rid of the bias
ed by the first view of the Nova before placing it and the
parison stars successively in the centre of the field. Sky foggy.
he 10-inch, power 90, Nova is ½ mag. fainter than No. 58.
ht moonlight (C.). The image of Nova in the 10-inch is sharp
in good focus with those of other stars. No nebulosity, but
sky is moonlit (W.).

nparing Nova with Nos. 65 and 64 in the 10-inch, using
er 90, I found it was necessary for the best definition to focus
star separately when in centre of field. The margin of the
ge of Nova seemed narrower to-night than on November 28.
64 is duller than No. 65, but I thought its image a trifle
er than No. 65. Sky is clear, but there is some ground-fog,
horizon stars are nearly obliterated (W.). Sky is somewhat
y, but the field around No. 64 seems blacker than that around
Nova (R.).

The observers were :—Mr. Wickham, indicated by W.
Mr. Robinson, „ R.
Mr. McClellan, „ C.

*Radcliffe Observatory, Oxford:*
1902 *June* 10.

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## *Further Observations of the New Star in Perseus* (5).

By A. Stanley Williams.

My early observations of this star up to 1901 June 10 have already been communicated to the Society.* The present paper contains the continuation up to the present time. The photometric magnitudes of a number of the fainter stars in the neighbourhood of the Nova have recently been published by Messrs. G. Müller and P. Kempf in the *Astronomische Nachrichten*, No. 3779, and these magnitudes have been adopted for the comparison stars in reducing the observations. The following is a list of the comparison stars used, with the magnitudes according to Müller and Kempf. The first column contains the designation of the star employed in the present observations.

*Comparison Stars.*

| Designation. | Name. | Magnitude. |
|---|---|---|
| (32) | 32 Persei | 5·18 |
| (36) | 36 Persei | 5·54 |
| (30) | 30 Persei | 5·65 |
| *b* | B.D. +43°·730 | 6·57 |
| *a* | „ +44°·734 | 6·61 |
| *c* | „ +43°·732 | 7·41 |
| *g* | „ +43°·729 | 8·70 |
| *h* | „ +43°·739 | 9·11 |

The above magnitudes have been used in reducing all the telescopic observations. But for those made with the opera-glass the magnitudes of *a* and *b* have been assumed to be 6·25 and 6·50. Both these stars are accompanied by bright companions, and the presence of the latter evidently affected the brightness as observed with the opera glass. The increase of brightness indicated by the above values is less than what should result from combining the light of the component stars of the two groups, but their adoption renders the opera-glass observations comparable with the telescopic.

According to the photometric observations *b* should be

* See *Monthly Notices*, vol. lxi. pp. 337, 396, 480 and 550.

ter than *a*, but visually the latter was decidedly the former. This difference is no doubt due to d colour of *b*,* and was greater with the $2\frac{3}{4}$-inch with the $6\frac{1}{2}$-inch reflector. All the observations luced with a step value of 0·07 mag. In the last e following table, $6\frac{1}{2} = 6\frac{1}{2}$-inch reflector, p. 50; refractor, p. 35; $1\frac{1}{2}$ = the $1\frac{1}{2}$-inch finder of the 2; and Op. = opera-glass.

*Observations of Brightness of the Nova.*

| M.T. | Observations. | Magnitude. | Inst. |
|---|---|---|---|
| m | | | |
| 20 | (36) 9 N 6 *a* | 6·18 | $2\frac{3}{4}$ |
| 5 | (36) 8 N 7 *a* | 6·11 | ,, |
| 10 | (36) 8 N 8 *a* | 6·07 | ,, |
| 40 | (36) 12 N 3 *a* | 6·39 | ,, |
| 15 | (36) 12 N 3*a*, N 8 *b* | 6·26 | ,, |
| 0 | (36) 10 N 5 *a* | 6·25 | ,, |
| 25 | (36) 10 N 5 *a*, (30) 10 N | 6·28 | ,, |
| 40 | *a* = N 7 *b* | 6·34 | ,, |
| 30 | (36) = N 12 *a*, (30) = N, (32) 5 N | 5·62 | ,, |
| 15 | (32) 4 N 15 *a*, N 2 (36), N 2 (30) | 5·46 | ,, |
| 52 | (32) 2 N 3 (36), N 3 (30) | 5·36 | ,, |
| 40 | (36) 8 N 5 *a* | 6·18 | ,, |
| 10 | (36) 9 N 5 *a*, (30) 10 N | 6·26 | ,, |

| Date. 1901. | G.M.T. h m | Observations. | Magnitude. | Inst. |
|---|---|---|---|---|
| Aug. 8 | 15 0 | N 2 *a*, N 10 *b* | 6·17 | 1½ |
| 8 | 15 0 | N 2 *a*, N 10 *b* | 6·17 | 2¾ |
| 9 | 10 55 | (36) 8 N 7 *a*, (30) 10 N 15 *b* | 6·02 | ,, |
| 10 | 12 50 | (36) 13 N = *a*, N 8 *b* | 6·36 | ,, |
| 10 | 15 0 | *a* = N 5 *b* | 6·41 | ,, |
| 10 | 15 0 | *a* 1 N | 6·32 | Op. |
| 11 | 14 20 | (36) 10 N 3 *a*, N 10 *b* | 6·17 | 2¾ |
| 11 | 14 20 | *a* 1 N | 6·32 | Op. |
| 12 | 12 5 | N 1 *a*, N 8 *b* | 6·27 | 2¾ |
| 15 | 11 0 | *a* = N 3 *b*, N 10 *c* | 6·56 | ,, |
| 15 | 13 5 | *a* 3 N | 6·46 | Op. |
| 15 | 13 15 | *a* = N 3 *b* | 6·48 | 2¾ |
| 16 | 11 20 | *a* 3 N | 6·46 | Op. |
| 16 | 11 30 | *a* = N 1 *b*, N 10 *c* | 6·61 | 2¾ |
| 16 | 13 47 | *a* 3 N 3 *b* | 6·37 | Op. |
| 18 | 10 55 | *a* = N 5 *b*, N 12 *c* | 6·47 | 2¾ |
| 18 | 13 15 | *a* 3 N 2 *b* | 6·41 | Op. |
| 18 | 14 8 | *a* 2 N 2 *b*, N 10 *c* | 6·63 | 2¾ |
| 19 | 11 15 | N 1 *a*, N 5 *b*, N 12 *c* | 6·44 | ,, |
| 19 | 14 8 | N 2 *a*, N 7 *b*, N 12 *c* | 6·37 | ,, |
| 19 | 14 8 | *a* 2 N 2 *b* | 6·37 | Op. |
| 20 | 11 0 | *a* 3 N 3 *b* | 6·37 | ,, |
| 20 | 11 20 | *a* = N 4 *b*, N 12 *c* | 6·49 | 2¾ |
| 20 | 14 0 | *a* = N 4 *b*, N 12 *c* | 6·49 | ,, |
| 21 | 10 5 | *a* 4 N 1 *b* | 6·48 | Op. |
| 21 | 11 5 | *a* 2 N 2 *b*, N 10 *c* | 6·63 | 2¾ |
| 21 | 14 10 | *a* 4 N 1 *b* | 6·48 | Op. |
| 22 | 10 45 | *a* = N 5 *b* | 6·20 | ,, |
| 22 | 11 54 | *a* = N 3 *b*, N 12 *c* | 6 51 | 2¾ |
| 22 | 13 30 | *a* 3 N 2 *b* | 6·41 | Op. |
| 22 | 14 45 | *a* 3 N 2 *b* | 6·41 | ,, |
| 23 | 11 10 | *a* 2 N 2 *b*, N 10 *c* | 6·63 | 2¾ |
| 23 | 14 10 | *a* 2 N 2 *b* | 6·37 | Op. |
| 24 | ? | *a* 5 N = *b* | 6·55 | ,, |
| 24 | 13 35 | *a* 3 N = *b*, N 12 *c* | 6·65 | 2¾ |
| 26 | 10 47 | *a* 4 N = *b*, N 10 *c* | 6·72 | ,, |
| 26 | 14 47 | *a* 2·5 N 3·5 *b* | 6·34 | Op. |
| 26 | 14 47 | *a* 3 N = *b* | 6·69 | 6½ |
| 27 | 13 55 | *a* 3 N 1 *b*, N 12 *c* | 6·63 | 2¾ |

| G.M.T. | Observations. | Magnitude. | Inst. |
|---|---|---|---|
| h m | | | |
| 5 5 | *a* 6 N, *b* 3 N 10 *c* | 6·84 | 6½ |
| 5 45 | *a* 3 N = *b*, N 12 *c* | 6·65 | 2¾ |
| 6 13 | *a* 5 N, *b* 3 N 6 *c* | 6·91 | 6½ |
| 6 30 | *a* 5 N = *b* | 6·55 | Op. |
| 6 35 | *a* 3 N = *b*, N 12 *c* | 6·65 | 2¾ |
| 6 48 | *a* 5 N = *b* | 6·55 | Op. |
| 7 5 | *a* 4 N, *b* 1 N 10 *c* | 6·75 | 2¾ |
| 7 12 | *a* 4 N 1 *b* | 6·48 | Op. |
| 7 8 | N 2 *a*, N 5 *b* | 6·34 | 2¾ |
| 8 50 | N 3 *a*, N 6 *b* | 6·27 | ,, |
| 9 40 | *a* 2 N = *b*, N 8 *c* | 6·72 | 6½ |
| 9 15 | *a* 4 N 1 *b* | 6·48 | Op. |
| 9 0 | *a* 4 N 2 *b* | 6·44 | ,, |
| 9 0 | *a* 5 N = *b* | 6·55 | ,, |
| 9 0 | *a* 4 N 1 *b* | 6·48 | ,, |
| 9 30 | *a* 3 N 2 *b* | 6·41 | ,, |
| 9 2 | *a* 5 N 0·5 *b* | 6·53 | ,, |
| 10 15 | *a* 5 N 1 *b* | 6·51 | ,, |
| 10 30 | *a* 5 N 1 *b* | 6·51 | ,, |
| 11 25 | *a* 5 N 1 *b* | 6·51 | ,, |
| 12 10 | *a* 4 N 2 *b* | 6·44 | ,, |
| 12 35 | *a* 7 N = *b* | 6·62 | ,, |

*Notes.*

1901.
June 26. A little hazy.
July 28. Object-glass slightly dewed in last observation.
Aug. 3. Thin cirrus cloud may have slightly affected the result.
4. A little thin cloud about.
9. Very clear generally, but patches of haze.
Sept. 1. Slight haze. Sky very bright.
Dec. 10. Exceedingly clear. Nova just distinctly visible in the opera-glass.

Excepting where otherwise noted above, it may be assumed that the conditions were favourable.

The observations show that there was a decided temporary increase in the brightness of the Nova on 1901 June 24; but this seems to be the last instance of the kind, the remarkable fluctuations in brightness having almost completely subsided after this date. I feel confident, however, that some of the smaller changes recorded later were real, and not due simply to errors of observation. In particular the increased brightness of the star on September 5 was undoubtedly real. Apart from these slight changes there has been a nearly continuous decline in brightness. The Nova was seen for the last time with the opera glass on December 10, an exceedingly clear night.

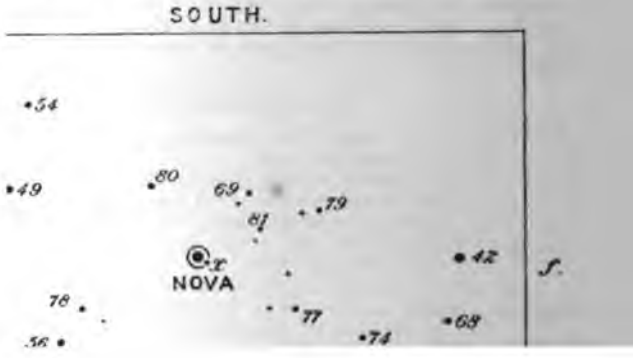
*Notes on the Colour of the Star.*

1901.
June 14. Little or no red colour, though appearance not the same as that of the comparison stars.
17. Colour seemed strongly reddish, but not more so than *b*.
23. Colour reddish, but not at all marked, and there even seemed at times to be a bluish tinge.
24. Yellowish with pale reddish flashes. On the whole the star was not as red as 36 Persei.
27. Hardly any red colour perceptible.
July 29. Hardly any red colour. The star was indeed slightly bluish, with an occasional yellowish red tinge. It was not nearly so red as *b*.
Aug. 6. Little or no red colour. Certainly not nearly so red as *b*.
8. Quite white, no red colour. No red colour with 6½-inch refl., not even with a Kellner eyepiece which greatly intensifies yellow and red tints.
10. Bluish white, with perhaps occasionally a slight yellowish tinge.
11. Bluish white, with occasional pale reddish flashes.
12. Very pale reddish, not nearly so deep as *b*.
15. White, with occasionally a faint tinge of red or yellow.
18. White (6½-inch. refl. Kellner).
20. White.
22. White, with perhaps a slight reddish or yellowish tinge.
23. White.
26. White (6½-inch refl.). Nova had a perfectly stellar disc, with no trace of nebulosity.
27. White.
30. White (6½-inch refl.). The contrast between the orange red of *b* and the white of the Nova was very striking.
Sept. 1. White.
5. White, with perhaps a slight bluish tinge at times. With the 6½-inch refl. white.
Nov. 1. Bluish white, even with the Kellner (6½-inch refl.).
Dec. 10. Colour seemed slightly greenish.
1902.
Jan. 14. Colour seemed bluish.
31. Distinctly bluish.

All the foregoing observations were made with the 2¾-inch refractor except where otherwise mentioned.

*On the Photograph of* 1901 *February* 20.

rticulars of this photograph will be found in the *ices*, vol. lxi. p. 337. As it appears that this was ograph taken before the apparition of the Nova, it atter of some interest to determine the magnitude est star shown by it. Visual estimates of the of the fainter stars in this region have been published agen * and Professor Aitkin.† The former used a ctor, the latter a 36-inch refractor. The positions the stars in the accompanying diagram have been



| Star. | Aitkin. | Hagen. | Star. | Aitkin. | Hagen. |
|---|---|---|---|---|---|
| 49 | ... | 11·0 | 77 | 13 0 | 12·7 |
| 54 | ... | 11·4 | 78 | 13·2 | 12·8 |
| 56 | 12·5 | 11·4 | 80 | 13·0 | (13) |
| 68 | ... | 12·1 | *x* | 13·8 | ... |
| 74 | ... | 12·4 | | | |

It seems certain from the foregoing list that if the new star had been as bright as 12·5 mag. on the photometric scale,* it must have left an impression upon this plate, unless it was of a red colour at the time.

In the *Astronomische Nachrichten*, No. 3755, Professor Ceraski has drawn attention to a star of about the 12th magnitude found by M. Blajko upon one of the Moscow photographs† very near to the place of the Nova, which star was completely invisible in a 15-inch refractor in 1901 December. What appears to be the same star is shown, not only by the photograph of 1901 February 20, but also by several other of my photographs of earlier date. The coordinates of the position of the star given by Ceraski are

$$\alpha = \alpha \text{ Nova} + 0^{s}\cdot 31 \qquad \delta = \delta \text{ Nova} - 7''.$$

Those from measures of the plate of 1901 February 20 are (for 1855)

$$\alpha = \alpha \text{ Nova} + 0^{s}\cdot 88. \qquad \delta = \delta \text{ Nova} + 7''.$$

These positions though not identical are so close that they doubtless refer to the same object. A high degree of accuracy is not to be expected from my measures, as the focal length of the portrait lens with which the photograph was taken is rather short (about 20 inches), and the star discs, even of the faintest stars, are somewhat large, owing to the region of the Nova falling near the edge of the plate. Nevertheless I do not think that the above difference of position can be in error by more than five seconds of arc. The position of $x$ was measured on the plate of 1901 February 20; that of the Nova on a photograph taken on 1902 March 4, by which time the star had faded so much that its image is not very large. The two photographs were taken with the same instrument and under almost exactly similar conditions, and there can be no question as to a possible identification of the Nova with $x$. The faint star *Hagen* 80 is plainly visible on both plates, and it is evident, even to the eye, that the distance between this star and $x$ is greater than that between it and the Nova.

The question as to what has become of $x$ is a somewhat interesting one. As already stated it was invisible with the

* Hagen's magnitudes agree closely with the photometric determinations of Müller and Kempf down to the 9th magnitude.

† The photograph was obtained 1899 January 30.

cow refractor in 1901 December, whilst Aitkin eive it with the Lick 36-inch refractor in the spring year.* It is, of course, possible that it is a long ble, so that its invisibility may be only temporary, ographs do not seem to indicate variability. As tioned it is shown on several of the photographs and the following are the estimated photographic f $x$ on the different plates, assuming Hagen's visual for the stars 49 and 54, and a step value of 0·07

| ate. | Observations. | Magnitude. |
|---|---|---|
| Dec. 22 | (49) 7 $x$, (54) 10 $x$ | 11·79 |
| Jan. 15 | (49) 12 $x$, (54) 10 $x$ | 11·97 |
| 25 | (49) 12 $x$, (54) 10 $x$ | 11·97 |
| Feb. 20 | (49) 10 $x$, (54) 9 $x$ | 11·86 |

be seen that there is here little indication of The star is also said to be about 12 mag. on the ograph of 1899 January 30.

2 *May* 20.

above was written Professor Ceraski has very kindly enlarged print from the Moscow photograph of 30. This shows that the brightness of M. Blajko's the same as that of the star $x$ upon my photo- e position, however, although very close, does not quite identical, so that it is difficult to conclude

## *Nova Persei.* By Thos. W. Backhouse.

The following table gives details of my observations of Nova *Persei*:—Column 1 gives the date, column 2 the Greenwich mean time of the observation, column 3 the power of instrument used, 4 denoting opera-glasses, 9 the finder, and 20 a $4\frac{1}{4}$-inch refracting telescope. o.f. in this column denotes that the instrument was out of focus. Column 4 gives the assumed relative absorption for the night, calling it 1·0 when it is as clear as it is ever likely to be at the place of observation; column 5 gives the assumed zenithal absorption in magnitude; column 6 gives the calculated value of a step, column 7 the resulting magnitudes of the Nova, and 8 the comparison stars.

The last column is reserved for any notes to the observations, as hindrances &c. When the observation is made anywhere else than at Sunderland the place of observation is given in this column.

The method of comparison used is that of Argelander, namely, by step estimations, the Nova being compared with the stars named in column 8. First the magnitudes of the comparison stars in each sequence were computed, using as standards the Harvard photometric magnitudes taken from the Harvard Photometry, with the exception of those for *t*, *v*, *w*, and $y^2$, which are from the Harvard Durchmusterung. An allowance has been made in the case of *β Geminorum*, *κ Persei*, *t*, and $y^2$, on account of their ruddy colour, such stars appearing fainter to me than to the Harvard observers. Then an average of these resulting magnitudes for each star was taken, and these averages were adopted as standards for computing the Nova.

*t* and $y^2$ have sometimes been observed, but have not been used for obtaining the magnitude of the Nova unless inserted in column 8. Allowance has been made for atmospheric absorption in the cases where it is given in columns 4 and 5; in other cases it was not thought it would appreciably affect the result.

The stars with which the Nova has been compared are in *Perseus*, with the exception of *Capella*, *α Canis Minoris*, and *α* and *β Geminorum*, but I have used letters to denote the smaller stars, their identification being as follows:—

| | |
|---|---|
| $u$ = 36 Persei | $v$ = B.D.+44°, 757 } |
| $s$ = B.D.+45°, 811 | „ 759 } |
| $z$ = B.A.C. 1172 | $w$ = „ +43°, 730 |
| $r$ = B.D.+45°, 804 | $y$ = „ +44°, 734 |
| $t$ = „ +44°, 648 | $y^2$ = „ +44°, 732 |

When the observation of *y* is thought to have included the

tar $y^2$, the observed magnitude of the combination

ıd magnitudes of the stars are given below with hotometric value.

| Adopted Mag. | Harvard Mag. | | Adopted Mag. | Harvard Mag. |
|---|---|---|---|---|
| 0·49 | 0·46 | 30 Persei | 5·47 | 5·37 |
| 1·29 | 1·12 | *s* | 5·57 | 5·64 |
| 1·66 | 1·56 | *z* | 5·74 | 5·71 |
| 1·98 | 1·94 | *r* | 5·96 | 6·14 |
| 2·19 | 2·31 | $y, \beta\ y^2$ | 6·04 | 5·80 |
| 3·04 | 3·04 | *y* | 6·27 | 6·04 |
| 4·00 | 4·00 | *t* | 6·75 | 6·37 |
| 4·11 | 3·95 | *v* | 6·60 | 6·82 |
| 4·89 | 4·84 | *w* | 6·74 | 6·91 |
| 5·35 | 5·40 | $y^2$ | ... | 7·32 |

some of the stars were observed in darker sky the same comparison, but no account has been ıs the differences would only be slight.

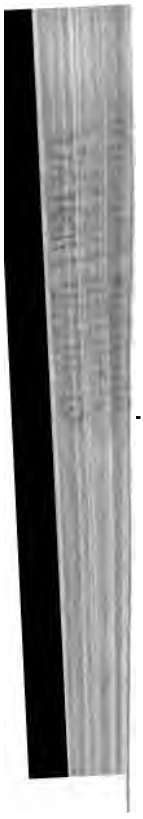
ıes where the step value came out very high an of ·07 magnitude has been used.

the ruddy colour of the Nova during a consider- ts apparition it did not appear to be relatively ·ilight or moonlight than in a dark sky, as ruddy

| Date. 1901. | G.M.T. h m | Power. | Rel. Abs. | Z. Abs. | S. Value. | Mag. of Nova. | Comparison Stars. | Notes. |
|---|---|---|---|---|---|---|---|---|
| Feb. 27 | 9 35 | ... | 1·5 | ·356 | ·065 | 1·46 | β Gem., α Gem. | Bright moonlight. |
| Mar. 1 | 10 20 | ... | 1·4 | ·344 | ·085 | 2·10 | α, β. | |
| 2 | 7 10 | .... | ... | ... | ·153 | 2·51 | „ | Moonlight. Altitudes practically equal. |
| 3 | 9 50 | ... | 1·0 | ·296 | ·068 | 2·41 | α, β, ε. | Bright moonlight. |
| 5 | 7 17 | ... | ... | ... | ·07 | 2·54 | „ | Altitudes equal. |
| 7 | 7 55 | ... | ... | ... | ·079 | 2·91 | β, ε. | „ „ |
| 8 | 9 0 | ... | ... | ... | ·075 | 3·12 | ε | „ „ |
| 9 | 10 55 | ... | ... | ... | ·099 | 3·40 | ε, ν. | „ „ |
| 12 | 9 5 | ... | ... | ... | ·067 | 3·52 | „ | „ „ |
| 13 | 8 35 | ... | ... | ... | ·075 | 3·80 | „ | Shields. Altitudes equal. |
| 20 | 7 40 | ... | 1·0 | ·296 | ·094 | 3·60 | „ | Twilight. |
| 20 | 10 20 | ... | 1·0 | ·263 | ·078 | 3·67 | „ | |
| 21 | 9 15 | ... | 1·0 | ·263 | ·082 | 3·86 | „ | |
| 21 | 11 45 | ... | ... | ... | ... | 4·00 | ν | Nova = ν Persei. Altitudes equal. |
| 23 | 7 51 | ... | 1·0 | ·296 | ·067 | 3·85 | ε, ν. | Stockton. Twilight. |
| 23 | 8 20 | ... | 1·0 | ·279 | ·067 | 3·85 | „ | Norton, near Stockton. Slight moonlight. |
| 25 | 10 53 | 4 o.f. | ... | ... | ·068 | 5·44 | ν, 32, 30 | Altitudes equal. |
| 26 | 10 20 | 4 o.f. | 1·0 | ·296 | ·102 | 4·10 | ν, 32. | Bright moonlight. |
| 26 | 11 50 | 4 o.f. | 1·0 | ·296 | ·079 | 4·00 | „ | „ „ |
| 28 | 9 15 | 4 o.f. | 1·4 | ·344 | ·055 | 5·00 | 32, 30 | „ „ |
| 28 | 11 35 | 4 o.f. | 1·4 | ·344 | ·066 | 4·80 | ν, 32 | „ „ |
| 28 | 12 0 | 4 o.f. | 1·2 | ·320 | ·063 | 4·85 | „ | „ „ |
| 28 | 16 18 | 4 o.f. | 1·0 | ·296 | ·04 | 4·73 | „ | Twilight. |
| 30 | 8 40 | 4 o.f. | 1·0 | ·296 | ... | 3·99 | ν | Nova = ν. Brt. moonlight. |
| 31 | 8 5 | 4 o.f. | ... | ... | ·064 | 4·40 | ν, 32 | Brt. moonlight, alts. equal. |
| 31 | 8 42 | 4 o.f. | ... | ... | ·054 | 4·39 | „ | „ „ |
| 31 | 9 17 | 4 o.f. | ... | ... | ·055 | 4·39 | „ | „ „ |
| 31 | 9 58 | 4 o.f. | ... | ... | ·056 | 4·35 | „ | „ „ |
| 31 | 10 27 | 4 o.f. | ... | ... | ·056 | 4·35 | „ | „ „ |
| 31 | 11 41 | 4 o.f. | ... | ... | ·06 | 4·34 | „ | Bright moonlight, altitudes practically equal. |
| Apr. 1 | 7 56 | 4 o.f. | 1·1 | ·308 | ·064 | 4·19 | „ | Bright twilight and moonlight. |

| Rel. Abs. | Z. Abs. | S. Value. | Mag. of Nova. | Comparison Stars. | Notes. |
|---|---|---|---|---|---|
| 1·1 | ·308 | ·073 | 4·33 | *ν*, 32 | Bright moonlight. |
| 1·1 | ·308 | ·066 | 4·30 | „ | „ „ |
| 1·1 | ·308 | ·06 | 4·31 | „ | „ „ |
| ... | ... | ·079 | 4·17 | „ | Bright twilight, altitudes practically equal. |
| ... | ... | ·079 | 4·17 | „ | Brightish twilight, altitudes practically equal. |
| ... | ... | ·087 | 4·10 | „ | Brightish moonlight or twilight, alts. equal. |
| ... | ... | ·073 | 4·16 | „ | Bright moonlight, altitudes equal. |
| ... | ... | ·076 | 4·12 | „ | „ „ |
| 1·0 | ·296 | ·07 | 4·12 | „ | Bright moonlight. |
| 1·0 | ·279 | ·073 | 4·40 | „ | Slight twilight or moonlight. |
| 1·0 | ·296 | ·066 | 4·40 | „ | Moonlight. |
| 1·0 | ·296 | ·075 | 4·53 | „ | South Shields. Twilight. |
| 1·0 | ·263 | ·07 | 4·46 | „ | |
| 1·0 | ·263 | ·063 | 4·41 | „ | |
| 1·1 | ·308 | ·037 | 4·35 | „ | Bright twilight and moonlight. |

| Date. 1901. | G.M.T. h | m | Power. | Rel. Abs. | Z. Abs. | S. Value. | Mag. of Nova. | Comparison Stars. | Notes. |
|---|---|---|---|---|---|---|---|---|---|
| Apr. 14 | 15 | 15 | 4 | 1·0 | ·263 | ·063 | 5·74 | 30; $\varepsilon$; $y$ | W. Hartlep'l. Twilight. |
| | 15 | 33 | 4 | 1·0 | ·263 | ·195 | 5·69 | 30, $\varepsilon$ | ,, ,, Step value assumed ·07 mag. Brightish twilight. |
| 15 | 8 | 44 | 4 o.f. | ... | ... | ·045 | 5·59 | ,, | Twilight. Alts. equal. |
| | 9 | 15 | 4 o.f. | ... | ... | ·066 | 5·67 | ,, | Slight twilight. Alts. equal |
| 16 | 10 | 35 | 9 o.f. | ... | ... | ·05 | 5·37 | 30 | Town light. Alts. equal |
| 18 | 15 | 28 | 4 | ... | ... | ·100 | 4·65 | $\kappa$; 32 | Hurworth. Alts. equal. |
| 20 | 9 | 5 | 4 | 1·3 | ·313 | ·06 | 5·74 | 30; $\varepsilon$ | Twilight. |
| | 9 | 34 | 4 o.f. | 1·7 | ·379 | ·032 | 5·65 | 30; $\varepsilon$; $y$ & $y^2$ | |
| 21 | 9 | 29 | 4 | 2·0 | ·423 | ·13 | 5·67 | 30, $\varepsilon$ | Slight twilight and moonlight. Step value assumed ·07 mag. |
| 24 | 9 | 47 | 4 o.f. | ... | ... | ·066 | 5·57 | ,, | Moonlight. Alts. equal. |
| 25 | 10 | 33 | 4 | 1·0 | ·263 | ·053 | 5·79 | 30; $\varepsilon$; $y$ | ,, |
| 26 | 9 | 22 | 4 | 1·0 | ·263 | ·048 | 5·72 | 30; $\varepsilon$ | ,, |
| May 4 | 10 | 5 | 20 | ... | ... | ·104 | 5·79 | 30; $y$ | Bright twilight. Alts. equal. |
| 15 | 10 | 9 | 4 | 1·2 | ·324 | ·049 | 5·85 | ,, | Torquay. Twilight. |
| 16 | 10 | 15 | 4 | 1·3 | ·330 | ·037 | 5·83 | ,, | ,, Brightish twilight. |
| 20 | 13 | 40 | 4 | 1·0 | ·263 | ·045 | 5·57 | 32; 30 | London. Brightish twilight. |
| 24 | 13 | 25 | 4 | 1·0 | ·263 | ·073 | 5·78 | 32; 30; $y$ | London. Brightish twilight. |
| June 1 | 12 | 20 | 20 o.f. | 1·0 | ·296 | ·063 | 5·77 | 30; $y$ | Bright twilight. |
| 5 | 12 | 10 | 20 o.f. | 1·0 | ·296 | ·066 | 5·92 | ,, | ,, ,, |
| | | | 20 | 1·0 | ·263 | ·061 | 6·05 | 32; $u$; 30; $y$; $v$; $w$ | ,, ,, |
| 8 | 11 | 10 | 20 | 1·5 | ·346 | ·076 | 4·69 | $\nu$; $\kappa$; 32; 30 | ,, ,, |
| 9 | 12 | 15 | 20 | 1·0 | ·263 | ·057 | 5·95 | 32; $u$; 30; $y$; $v$ | ,, ,, |
| 10 | 11 | 3 | 20 | 1·0 | ·263 | ·054 | 5·96 | 30; $y$ | ,, ,, |
| | 12 | 15 | 20 o.f. | 1·0 | ·296 | ·058 | 5·96 | ,, | ,, ,, |
| | 12 | 25 | 20 | 1·0 | ·263 | ·046 | 5·87 | ,, | ,, ,, |
| 11 | 11 | 12 | 20 | 1·0 | ·263 | ·056 | 5·03 | 32; 30 | ,, ,, |
| 12 | 11 | 20 | 20 | 1·0 | ·263 | ·073 | 5·85 | 30; $y$ | ,, ,, |
| | 11 | 35 | 20 | 1·0 | ·263 | ·063 | 5·90 | ,, | ,, ,, |



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 20 | 13 | 20 | 4 | o.f. | ... | ... | ·063 | 5·84 | |
| Aug. | 4 | 11 | 20 | 4 | | ... | ... | 063 | 6·03 | |
| | 19 | 13 | 0 | 4 | o.f. | ... | ... | ·066 | 5·94 | |
| | 21 | 11 | 50 | 4 | o.f. | ... | ... | ·063 | 5·89 | |
| | 22 | 10 | 40 | 4 | o.f. | ... | ... | ·063 | 5·94 | |
| | 24 | 10 | 40 | 20 | o.f. | ... | ... | ·063 | 6·18 | |
| | 26 | 11 | 50 | 4 | o.f. | ... | ... | ... | 6·04 | |
| | | 14 | 0 | 20 | o.f. | ... | ... | ·056 | 6·20 | u |
| | | 14 | 45 | 4 | o.f. | ... | ... | ·052 | 6·14 | u |
| | 27 | 10 | 40 | 4 | | ... | ... | ·063 | 6·14 | |
| | 28 | 10 | 40 | 20 | o.f. | ... | ... | ·051 | 6·26 | s |
| | 31 | 9 | 50 | 20 | o.f. | ... | ... | ·042 | 6·27 | |
| Sept. | 1 | 12 | 15 | 20 | o.f. | ... | ... | ·044 | 6·25 | s |
| | 4 | 10 | 15 | 4 | o.f. | ... | ... | ·042 | 6·06 | s |
| | | 10 | 30 | 20 | o.f. | ... | ... | ·069 | 6·29 | |
| | | 11 | 10 | 4 | | ... | ... | ·06 | 6·15 | |
| | 5 | 10 | 50 | 4 | o.f. | ... | ... | ·063 | 6·08 | s |
| | | 11 | 50 | 20 | o.f. | ... | ... | ·055 | 6·25 | |

| Date. 1901. | G.M.T. h | m | Power. | Rel. Abs. | Z. Abs. | S. Value. | Mag. of Nova. | Comparison Stars. | Notes. |
|---|---|---|---|---|---|---|---|---|---|
| Oct. 6 | 10 | 3 | 4 o.f. | ... | ... | ·063 | 6·40 | *y* & $y^2$; *v* | Alts. equal. |
| 7 | 10 | 25 | 4 o.f. | ... | ... | ·068 | 6·40 | ,, | ,, |
| 8 | 11 | 55 | 4 o.f. | ... | ... | ·063 | 6·40 | ,, | ,, |
| 9 | 9 | 42 | 20 o.f. | ... | ... | ·067 | 6·57 | *y*; *v* | ,, |
| 10 | 10 | 25 | 4 o.f. | ... | ... | ·078 | 6·42 | *y* & $y^2$; *v* | ,, |
| | 10 | 40 | 20 o.f. | ... | ... | ·078 | 6·51 | *y*; *v* | ,, |
| 11 | 10 | 30 | 4 o.f. | ... | ... | ·055 | 6·41 | *y* & $y^2$; *v* | ,, |
| 17 | 9 | 50 | 4 o.f. | ... | ... | ·063 | 6·43 | ,, | ,, |
| 25 | 10 | 50 | 20 o.f. | ... | ... | ·103 | 6·74 | *y*; *v* | ,, Moonlight. |
| Nov. 12 | 7 | 55 | 4 o.f. | ... | ... | ·063 | 6·66 | *t*; *v* | ,, |
| 15 | 8 | 15 | 4 o.f. | ... | ... | ·063 | 6·69 | ,, | ,, |

*West Hendon House, Sunderland.*

*Ephemeris for Physical Observations of*

| L−O. | B. | A−L. | *B*. | Q. | E. |
|---|---|---|---|---|---|
| 231°·89 | +20°·90 | ... | +10°·66 | 289°·26 | 29°·24 |
| 233·14 | 21·19 | ... | 11·02 | 289·56 | 29·51 |
| 234·39 | 21·47 | 29·22 | 11·38 | 289·85 | 29·79 |
| 235·64 | 21·74 | ... | 11·73 | 290·12 | 30·06 |
| 236·89 | 22·00 | ... | 12·08 | 290·38 | 30·33 |
| 238·14 | 22·25 | ... | 12·43 | 290·63 | 30·59 |
| 239·39 | 22·49 | 30·75 | 12·77 | 290·87 | 30·85 |
| 240·63 | 22·71 | ... | 13·11 | 291·10 | 31·11 |
| 241·88 | 22·92 | ... | 13·44 | 291·32 | 31·36 |
| 243·12 | 23·12 | ... | 13·77 | 291·53 | 31·61 |
| 244·36 | 23·31 | 32·24 | 14·10 | 291·73 | 31·86 |
| 245·60 | 23·48 | ... | 14·42 | 291·92 | 32·11 |
| 246·83 | 23·64 | ... | 14·74 | 292·10 | 32·34 |
| 248·06 | 23·79 | ... | 15·06 | 292·28 | 32·58 |
| 249·29 | 23·94 | 33·67 | 15·37 | 292·44 | 32·81 |
| 250·52 | 24·08 | ... | 15·68 | 292·59 | 33·04 |
| 251·74 | 24·20 | ... | 15·99 | 292·73 | 33·26 |
| 252·95 | 24·31 | ... | 16·29 | 292·86 | 33·48 |

*Mars*, 1902–3. By A. C. D. Crommelin.

| Greenwich Noon. 1902. | | ⊙ | Light Time. | Appar. Diam. | Defect of Illumination. | Central Meridian. | Passage of Zero Meridian. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ° | m | ″ | ″ | ° | h | m | h | m |
| Oct. | 5 | ... | 16·836 | 4·60 | 0·29 | 106·86 | 17 | 20·64 | 18 | 0·61 |
| | 7 | ... | 16·725 | 4·62 | 0·30 | 87·42 | 18 | 40·57 | 19 | 20·53 |
| | 9 | 27·46 | 16·612 | 4·66 | 0·31 | 67·98 | 20 | 0·49 | 20 | 40·45 |
| | 11 | ... | 16·498 | 4·69 | 0·32 | 48·54 | 21 | 20·40 | 22 | 0·36 |
| | 13 | ... | 16·383 | 4·72 | 0·33 | 29·10 | 22 | 40·31 | 23 | 20·25 |
| | 15 | ... | 16·264 | 4·76 | 0·33 | 9·67 | | ... | 0 | 0·19 |
| | 17 | 31·13 | 16·144 | 4·79 | 0·34 | 350·24 | 0 | 40·13 | 1 | 20·06 |
| | 19 | ... | 16·023 | 4·82 | 0·35 | 330·81 | 2 | 0·00 | 2 | 39·94 |
| | 21 | ... | 15·900 | 4·86 | 0·36 | 311·38 | 3 | 19·87 | 3 | 59·81 |
| | 23 | ... | 15·775 | 4·90 | 0·37 | 291·95 | 4 | 39·74 | 5 | 19·67 |
| | 25 | 34·77 | 15·648 | 4·94 | 0·37 | 272·52 | 5 | 59·60 | 6 | 39·52 |
| | 27 | ... | 15·519 | 4·98 | 0·38 | 253·10 | 7 | 19·44 | 7 | 59·36 |
| | 29 | ... | 15·388 | 5·02 | 0·39 | 233·68 | 8 | 39·28 | 9 | 19·19 |
| | 31 | ... | 15·256 | 5·07 | 0·40 | 214·26 | 9 | 59·10 | 10 | 39·00 |
| Nov. | 2 | 38·38 | 15·123 | 5·11 | 0·41 | 194·85 | 11 | 18·90 | 11 | 58·79 |
| | 4 | ... | 14·988 | 5·16 | 0·42 | 175·44 | 12 | 38·67 | 13 | 18·55 |
| | 6 | ... | 14·851 | 5·21 | 0·43 | 156·04 | 13 | 58·42 | 14 | 38·29 |
| | 8 | ... | 14·712 | 5·26 | 0·43 | 136·64 | 15 | 18·15 | 15 | 58·01 |
| | 10 | 41·97 | 14·572 | 5·31 | 0·44 | 117·25 | 16 | 37·87 | 17 | 17·72 |
| | 12 | ... | 14·430 | 5·36 | 0·45 | 97·86 | 17 | 57·56 | 18 | 37·40 |
| | 14 | ... | 14·287 | 5·41 | 0·46 | 78·48 | 19 | 17·23 | 19 | 57·05 |
| | 16 | ... | 14·143 | 5·47 | 0·47 | 59·10 | 20 | 36·86 | 21 | 16·66 |
| | 18 | 45·53 | 13·997 | 5·53 | 0·48 | 39·73 | 21 | 56·46 | 22 | 36·24 |
| | 20 | ... | 13·850 | 5·58 | 0·49 | 20·38 | 23 | 16·00 | 23 | 55·74 |
| | 22 | ... | 13·701 | 5·64 | 0·50 | 1·04 | | ... | 0 | 35·45 |
| | 24 | ... | 13·551 | 5·70 | 0·51 | 341·71 | 1 | 15·16 | 1 | 54·87 |
| | 26 | 49·08 | 13·400 | 5·77 | 0·52 | 322·39 | 2 | 34·57 | 3 | 14·26 |
| | 28 | ... | 13·248 | 5·84 | 0·53 | 303·08 | 3 | 53·94 | 4 | 33·61 |
| | 30 | ... | 13·094 | 5·91 | 0·54 | 283·78 | 5 | 13·27 | 5 | 52·92 |
| Dec. | 2 | ... | 12·939 | 5·98 | 0·55 | 264·49 | 6 | 32·56 | 7 | 12·18 |
| | 4 | 52·62 | 12·783 | 6·05 | 0·56 | 245·21 | 7 | 51·79 | 8 | 31·39 |
| | 6 | ... | 12·627 | 6·12 | 0·57 | 225·94 | 9 | 10·98 | 9 | 50·56 |
| | 8 | ... | 12·469 | 6·20 | 0·59 | 206·68 | 10 | 30·12 | 11 | 9·66 |
| | 10 | ... | 12·311 | 6·28 | 0·60 | 187·43 | 11 | 49·19 | 12 | 28·71 |
| | 12 | 56·14 | 12·152 | 6·36 | 0·61 | 168·20 | 13 | 8·23 | 13 | 47·70 |

| | L−Q. | B. | A−L. | B. | Q. | R. |
|---|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° | ″ |
| 7 | 273·38 | +24·49 | ... | +20·97 | 293·67 | 36·10 |
| 3 | 274·40 | 24·42 | ... | 21·19 | 293·64 | 36·15 |
| 8 | 275·40 | 24·34 | ... | 21·40 | 293·60 | 36·20 |
| 2 | 276·38 | 24·25 | 39·29 | 21·60 | 293·56 | 36·23 |
| 4 | 277·35 | 24·16 | ... | 21·80 | 293·51 | 36·24 |
| 4 | 278·30 | 24·06 | ... | 21·99 | 293·45 | 36·24 |
| 3 | 279·23 | 23·96 | ... | 22·18 | 293·38 | 36·22 |
| 1 | 280·14 | 23·85 | 39·38 | 22·36 | 293·30 | 36·18 |
| 8 | 281·03 | 23·73 | ... | 22·54 | 293·21 | 36·13 |
| 3 | 281·90 | 23·61 | ... | 22·71 | 293·11 | 36·06 |
| 7 | 282·75 | 23·49 | ... | 22·88 | 293·02 | 35·97 |
| 9 | 283·57 | 23·37 | 39·08 | 23·04 | 292·92 | 35·85 |
| 0 | 284·36 | 23·25 | ... | 23·20 | 292·82 | 35·72 |
| 0 | 285·13 | 23·12 | ... | 23·35 | 292·72 | 35·57 |
| 8 | 285·88 | 22·99 | ... | 23·50 | 292·61 | 35·40 |
| 4 | 286·60 | 22·86 | 38·37 | 23·64 | 292·50 | 35·20 |
| 9 | 287·29 | 22·73 | ... | 23·77 | 292·38 | 34·98 |
| 3 | 287·95 | 22·60 | ... | 23·90 | 292·26 | 34·73 |
| 5 | 288·59 | 22·47 | ... | 24·02 | 292·14 | 34·46 |
| 6 | 289·19 | 22·34 | 37·17 | 24·14 | 292·01 | 34·15 |
| 5 | 289·76 | 22·22 | | 24·25 | 291·87 | 33·82 |

| Greenwich Noon. 1902. | ⊙ | Light Time. | Apparent Diameter. | Defect of Illumination. | Central Meridian. | Passage of Zero Meridian. | |
|---|---|---|---|---|---|---|---|
| | ° | m | ″ | ″ | ° | h m | h m |
| Dec. 14 | ... | 11·992 | 6·45 | 0·62 | 148·99 | 14 27·16 | |
| | | | | | | | 15 6·61 |
| 16 | ... | 11·831 | 6·54 | 0·63 | 129·79 | 15 46·04 | |
| | | | | | | | 16 25·45 |
| 18 | ... | 11·670 | 6·63 | 0·64 | 110·61 | 17 4·84 | |
| | | | | | | | 17 44·20 |
| 20 | 59·64 | 11·508 | 6·72 | 0·65 | 91·45 | 18 23·53 | |
| | | | | | | | 19 2·84 |
| 22 | ... | 11·346 | 6·82 | 0·66 | 72·31 | 19 42·14 | |
| | | | | | | | 20 21·42 |
| 24 | ... | 11·183 | 6·92 | 0·67 | 53·19 | 21 0·68 | |
| | | | | | | | 21 39·92 |
| 26 | ... | 11·019 | 7·02 | 0·68 | 34·09 | 22 19·14 | |
| | | | | | | | 22 58·35 |
| 28 | 63·14 | 10·856 | 7·13 | 0·69 | 15·00 | 23 37·54 | |
| | | | | | | | ... |
| 30 | ... | 10·692 | 7·24 | 0·70 | 355·93 | 0 16·71 | |
| | | | | | | | 0 55·86 |
| 1903. | | | | | | | |
| Jan. 1 | ... | 10·528 | 7·35 | 0·71 | 336·88 | 1 34·99 | |
| | | | | | | | 2 14·08 |
| 3 | ... | 10·363 | 7·46 | 0·71 | 317·86 | 2 53·13 | |
| | | | | | | | 3 32·16 |
| 5 | 66·64 | 10·199 | 7·58 | 0·72 | 298·86 | 4 11·17 | |
| | | | | | | | 4 50·15 |
| 7 | ... | 10·036 | 7·70 | 0·73 | 279·89 | 5 29·10 | |
| | | | | | | | 6 8·03 |
| 9 | ... | 9·873 | 7·83 | 0·73 | 260·94 | 6 46·93 | |
| | | | | | | | 7 25·80 |
| 11 | ... | 9·710 | 7·96 | 0·74 | 242·02 | 8 4·63 | |
| | | | | | | | 8 43·43 |
| 13 | 70·13 | 9·548 | 8·10 | 0·75 | 223·13 | 9 22·21 | |
| | | | | | | | 10 0·96 |
| 15 | ... | 9·386 | 8·24 | 0·75 | 204·27 | 10 39·68 | |
| | | | | | | | 11 18·36 |
| 17 | ... | 9·225 | 8·38 | 0·75 | 185·43 | 11 57·01 | |
| | | | | | | | 12 35·63 |
| 19 | ... | 9·064 | 8·53 | 0·75 | 166·62 | 13 14·22 | |
| | | | | | | | 13 52·79 |
| 21 | 73·63 | 8·904 | 8·68 | 0·75 | 147·84 | 14 31·33 | |
| | | | | | | | 15 9·83 |
| 23 | ... | 8·745 | 8·84 | 0·74 | 129·09 | 15 48·29 | |
| | | | | | | | 16 26·70 |
| 25 | ... | 8·588 | 9·00 | 0·74 | 110·38 | 17 5·07 | |
| | | | | | | | 17 43·40 |
| 27 | ... | 8·432 | 9·17 | 0·74 | 91·70 | 18 21·70 | |
| | | | | | | | 18 59·96 |
| 29 | 77·12 | 8·277 | 9·34 | 0·73 | 73·06 | 19 38·18 | |
| | | | | | | | 20 16·35 |
| 31 | ... | 8·124 | 9·52 | 0·72 | 54·46 | 20 54·48 | |
| | | | | | | | 21 32·57 |
| Feb. 2 | ... | 7·974 | 9·70 | 0·72 | 35·90 | 22 10·62 | |
| | | | | | | | 22 48·63 |
| 4 | ... | 7·826 | 9·88 | 0·71 | 17·38 | 23 26·61 | |
| | | | | | | | ... |
| 6 | 80·62 | 7·679 | 10·07 | 0·69 | 358·89 | 0 4·56 | |
| | | | | | | | 0 42·44 |
| 8 | ... | 7·534 | 10·26 | 0·68 | 340·45 | 1 20·26 | |
| | | | | | | | 1 58·03 |
| 10 | ... | 7·392 | 10·46 | 0·66 | 322·05 | 2 35·76 | |
| | | | | | | | 3 13·44 |
| 12 | ... | 7·253 | 10·66 | 0·64 | 303·70 | 3 51·07 | |
| | | | | | | | 4 28·64 |
| 14 | 84·13 | 7·116 | 10·87 | 0·63 | 285·40 | 5 6·16 | |
| | | | | | | | 5 43·63 |
| 16 | ... | 6·983 | 11·08 | 0·61 | 267·14 | 6 21·06 | |
| | | | | | | | 6 58·44 |
| 18 | ... | 6·853 | 11·29 | 0·59 | 248·93 | 7 35·77 | |
| | | | | | | | 8 13·04 |
| 20 | ... | 6·726 | 11·50 | 0·56 | 230·77 | 8 50·25 | |
| | | | | | | | 9 27·40 |
| 22 | 87·65 | 6·603 | 11·71 | 0·53 | 212·67 | 10 4·49 | |
| | | | | | | | 10 41·52 |
| 24 | ... | 6·485 | 11·93 | 0·49 | 194·62 | 11 18·49 | |
| | | | | | | | 11 55·40 |

| | L—O. | B. | A—L. | B. | Q. | E. |
|---|---|---|---|---|---|---|
| 5 | 293°16 | +21°12 | ... | +25°21 | 288°56 | 22°24 |
| 7 | 292·90 | 21·14 | ... | 25·21 | 288·26 | 21·14 |
| 7 | 292·60 | 21·17 | 21·28 | 25·21 | 287·85 | 19·99 |
| 5 | 292·24 | 21·22 | ... | 25·20 | 287·33 | 18·78 |
| 2 | 291·83 | 21·28 | ... | 25·17 | 286·7 | 17·52 |
| 7 | 291·38 | 21·35 | ... | 25·14 | 286·1 | 16·21 |
| 0 | 290·87 | 21·43 | 15·63 | 25·11 | 285·3 | 14·86 |
| 2 | 290·30 | 21·52 | ... | 25·07 | 284·4 | 13·46 |
| 2 | 289·70 | 21·63 | ... | 25·03 | 283 | 12·02 |
| 0 | 289·07 | 21·74 | ... | 24·98 | 281 | 10·55 |
| 6 | 288·39 | 21·86 | 9·22 | 24·92 | 279 | 9·04 |
| 0 | 287·67 | 22·00 | ... | 24·86 | 277 | 7·52 |
| 3 | 286·91 | 22·14 | ... | 24·79 | 274 | 5·99 |
| 5 | 286·13 | 22·28 | ... | 24·71 | 270 | 4·46 |
| 6 | 285·34 | 22·42 | 2·23 | 24·62 | 264 | 3·05 |
| 6 | 284·53 | 22·56 | ... | 24·53 | ... | 2·04 |
| 4 | 283·70 | 22·71 | ... | 24·43 | ... | 2·14 |
| 0 | 282·85 | 22·85 | ... | 24·33 | 147 | 3·26 |
| 7 | 282·03 | 23·00 | 5·04 | 24·22 | 140 | 4·73 |
| 5 | 281·23 | 23·14 | ... | 24·10 | 134 | 6·29 |
| 3 | 280·45 | 23·29 | ... | 23·98 | 129 | 7·87 |

| Greenwich Noon. 1903. | ⊙ | Light Time. | Appar. Diam. | Defect of Illumination. | Central Meridian. | Passage of Zero Meridian. | |
|---|---|---|---|---|---|---|---|
| | ° | m | ″ | ″ | ° | h m | h m |
| Feb. 26 | ... | 6·372 | 12·14 | 0·45 | 176·63 | 12 32·25 | 13 9·05 |
| 28 | ... | 6·263 | 12·35 | 0·41 | 158·68 | 13 45·80 | 14 22·50 |
| Mar. 2 | 91·19 | 6·158 | 12·56 | 0·37 | 140·79 | 14 59·14 | 15 35·72 |
| 4 | ... | 6·058 | 12·77 | 0·33 | 122·95 | 16 12·24 | 16 48·69 |
| 6 | ... | 5·964 | 12·97 | 0·29 | 105·17 | 17 25·08 | 18 1·42 |
| 8 | ... | 5·875 | 13·16 | 0·25 | 87·44 | 18 37·71 | 19 13·95 |
| 10 | 94·73 | 5·791 | 13·35 | 0·21 | 69·76 | 19 50·15 | 20 26·31 |
| 12 | ... | 5·714 | 13·53 | 0·18 | 52·11 | 21 2·44 | 21 38·53 |
| 14 | ... | 5·643 | 13·70 | 0·15 | 34·50 | 22 14·58 | 22 50·56 |
| 16 | ... | 5·578 | 13·86 | 0·12 | 16·94 | 23 26·47 | ... |
| 18 | 98·30 | 5·520 | 14·01 | 0·09 | 359·44 | 0 2·30 | 0 38·12 |
| 20 | ... | 5·468 | 14·14 | 0·07 | 341·97 | 1 13·92 | 1 49·71 |
| 22 | ... | 5·423 | 14·26 | 0·04 | 324·51 | 2 25·49 | 3 1·25 |
| 24 | ... | 5·385 | 14·36 | 0·02 | 307·06 | 3 36·99 | 4 12·71 |
| 26 | 101·89 | 5·355 | 14·44 | 0·01 | 289·64 | 4 48·41 | 5 24·08 |
| 28 | ... | 5·332 | 14·50 | 0·00 | 272·25 | 5 59·72 | 6 35·33 |
| 30 | ... | 5·316 | 14·54 | 0·00 | 254·87 | 7 10·91 | 7 46·51 |
| Apr. 1 | ... | 5·307 | 14·56 | 0·01 | 237·49 | 8 22·12 | 8 57·76 |
| 3 | 105·51 | 5·305 | 14·57 | 0·02 | 220·09 | 9 33·52 | 10 9·19 |
| 5 | ... | 5·311 | 14·56 | 0·04 | 202·67 | 10 44·89 | 11 20·61 |
| 7 | ... | 5·323 | 14·53 | 0·06 | 185·25 | 11 56·34 | 12 32·09 |
| 9 | ... | 5·342 | 14·48 | 0·09 | 167·81 | 13 7·87 | 13 43·69 |
| 11 | 109·15 | 5·367 | 14·41 | 0·13 | 150·34 | 14 19·56 | 14 55·48 |
| 13 | ... | 5·399 | 14·32 | 0·16 | 132·82 | 15 31·45 | 16 7·46 |
| 15 | ... | 5·437 | 14·22 | 0·21 | 115·25 | 16 43·52 | 17 19·62 |
| 17 | ... | 5·481 | 14·10 | 0·26 | 97·65 | 17 55·76 | 18 31·94 |
| 19 | 112·82 | 5·531 | 13·97 | 0·31 | 80·01 | 19 8·16 | 19 44·44 |
| 21 | ... | 5·587 | 13·83 | 0·36 | 62·33 | 20 20·78 | 20 57·19 |
| 23 | ... | 5·648 | 13·68 | 0·41 | 44·58 | 21 33·66 | 22 10·19 |
| 25 | ... | 5·713 | 13·53 | 0·46 | 26·78 | 22 46·78 | 23 23·42 |
| 27 | 116·52 | 5·783 | 13·37 | 0·51 | 8·92 | ... | 0 0·12 |
| 29 | ... | 5·857 | 13·20 | 0·56 | 351·01 | 0 36·88 | 1 13·71 |
| May 1 | ... | 5·936 | 13·03 | 0·61 | 333·04 | 1 50·61 | 2 27·58 |
| 3 | ... | 6·019 | 12·85 | 0·65 | 315·01 | 3 4·61 | 3 41·70 |
| 5 | 120·26 | 6·105 | 12·67 | 0·69 | 296·92 | 4 18·84 | 4 56·06 |
| 7 | ... | 6·194 | 12·49 | 0·73 | 278·76 | 5 33·35 | 6 10·72 |
| 9 | ... | 6·287 | 12·30 | 0·77 | 260·55 | 6 48·16 | 7 25·64 |
| 11 | ... | 6·382 | 12·11 | 0·81 | 242·28 | 8 3·17 | 8 40·74 |

| | L–O. | B. | A–L. | *B.* | Q. | E. |
|---|---|---|---|---|---|---|
| | | ° | ° | ° | ° | ° |
| 12 | 273·55 | +25·29 | 33·19 | +20·64 | 114·39 | 30·80 |
| 18 | 273·68 | 25·36 | ... | 20·39 | 114·29 | 31·63 |
| 26 | 273·87 | 25·43 | ... | 20·14 | 114·19 | 32·41 |
| 37 | 274·11 | 25·50 | ... | 19·88 | 114·10 | 33·15 |
| 50 | 274·40 | 25·56 | 36·26 | 19·62 | 114·01 | 33·85 |
| 65 | 274·73 | 25·62 | ... | 19·35 | 113·94 | 34·51 |
| 82 | 275·11 | 25·68 | ... | 19·07 | 113·88 | 35·13 |
| 01 | 275·54 | 25·73 | ... | 18·79 | 113·82 | 35·72 |
| 22 | 276·02 | 25·77 | 38·55 | 18·50 | 113·76 | 36·26 |
| 45 | 276·53 | 25·80 | ... | 18·21 | 113·71 | 36·77 |
| 70 | 277·08 | 25·83 | ... | 17·91 | 113·66 | 37·25 |
| 95 | 277·66 | 25·85 | ... | 17·61 | 113·62 | 37·70 |
| 22 | 278·29 | 25·86 | 40·18 | 17·30 | 113·58 | 38·11 |
| 52 | 278·97 | 25·87 | ... | 16·98 | 113·54 | 38·50 |
| 82 | 279·67 | 25·87 | ... | 16·66 | 113·50 | 38·86 |
| 12 | 280·40 | 25·86 | ... | 16·33 | 113·46 | 39·20 |
| 44 | 281·15 | 25·85 | 41·22 | 16·00 | 113·42 | 39·5 |
| 76 | 281·93 | 25·84 | ... | 15·66 | 113·37 | 39·79 |
| 08 | 282·74 | 25·82 | ... | 15·32 | 113·33 | 40·05 |
| 41 | 283·58 | 25·79 | ... | 14·97 | 113·28 | 40·29 |
| 75 | 284·43 | 25·75 | 41·83 | 14·61 | 113·24 | 40·51 |

| Greenwich Noon. 1903. | ⊙ | Light Time. | Appar. Diam. | Defect of Illumination. | Central Meridian. | Passage of Zero Meridian | |
|---|---|---|---|---|---|---|---|
| | ° | m | ″ | ″ | ° | h m | h m |
| May 13 | 124·03 | 6·480 | 11·93 | 0·84 | 223·97 | 9 18·35 | 9 56·03 |
| 15 | ... | 6·580 | 11·75 | 0·87 | 205·60 | 10 33·78 | 11 11·61 |
| 17 | ... | 6·682 | 11·57 | 0·90 | 187·17 | 11 49·51 | 12 27·46 |
| 19 | ... | 6·786 | 11·39 | 0·93 | 168·69 | 13 5·45 | 13 43·48 |
| 21 | 127·85 | 6·893 | 11·22 | 0·96 | 150·16 | 14 21·56 | 14 59·70 |
| 23 | ... | 7·001 | 11·05 | 0·98 | 131·58 | 15 37·90 | 16 16·16 |
| 25 | ... | 7·110 | 10·89 | 1·00 | 112·95 | 16 54·48 | 17 32·84 |
| 27 | ... | 7·221 | 10·73 | 1·01 | 94·28 | 18 11·23 | 18 49·66 |
| 29 | 131·71 | 7·333 | 10·56 | 1·02 | 75·57 | 19 28·12 | 20 6·64 |
| 31 | ... | 7·445 | 10·39 | 1·04 | 56·82 | 20 45·22 | 21 23·84 |
| June 2 | ... | 7·558 | 10·23 | 1·05 | 38·02 | 22 2·51 | 22 41·22 |
| 4 | ... | 7·672 | 10·08 | 1·06 | 19·18 | 23 19·96 | 23 58·73 |
| 6 | 135·61 | 7·787 | 9·93 | 1·07 | 0·31 | ... | 0 37·53 |
| 8 | ... | 7·903 | 9·79 | 1·07 | 341·41 | 1 16·37 | 1 55·24 |
| 10 | ... | 8·018 | 9·65 | 1·08 | 322·46 | 2 34·14 | 3 13·11 |
| 12 | ... | 8·134 | 9·51 | 1·08 | 303·47 | 3 52·14 | 4 31·22 |
| 14 | 139·56 | 8·250 | 9·37 | 1·08 | 284·47 | 5 10·32 | 5 49·41 |
| 16 | ... | 8·366 | 9·24 | 1·07 | 265·45 | 6 28·51 | 7 7·62 |
| 18 | ... | 8·483 | 9·11 | 1·07 | 246·40 | 7 46·76 | 8 25·94 |
| 20 | ... | 8·599 | 8·99 | 1·07 | 227·32 | 9 5·16 | 9 44·41 |
| 22 | 143·56 | 8·715 | 8·87 | 1·07 | 208·22 | 10 23·70 | 11 3·03 |
| 24 | ... | 8·831 | 8·75 | 1·06 | 189·08 | 11 42·39 | 12 21·79 |
| 26 | ... | 8 946 | 8·64 | 1·06 | 169·90 | 13 1·22 | 13 40·68 |
| 28 | ... | 9 061 | 8·53 | 1·06 | 150·70 | 14 20·16 | 14 59·66 |
| 30 | 147·61 | 9·176 | 8·42 | 1·05 | 131·48 | 15 39·17 | 16 18·70 |
| July 2 | ... | 9·291 | 8·32 | 1·04 | 112·25 | 16 58·24 | 17 37·79 |
| 4 | ... | 9·405 | 8·22 | 1·04 | 93·00 | 18 17·35 | 18 56·94 |
| 6 | ... | 9·519 | 8·12 | 1·03 | 73·73 | 19 36 55 | 20 16·19 |
| 8 | 151·72 | 9·632 | 8·03 | 1·02 | 54·45 | 20 55·85 | 21 35·52 |
| 10 | ... | 9·744 | 7·94 | 1·01 | 35·15 | 22 15·20 | 22 54·90 |
| 12 | ... | 9 856 | 7·85 | 1·00 | 15·84 | 23 34·61 | ... |
| 14 | ... | 9·967 | 7·76 | 0·99 | 356·51 | 0 14·34 | 0 53·08 |
| 16 | 155·88 | 10·078 | 7·67 | 0·98 | 337·17 | 1 33·83 | 2 13·61 |
| 18 | ... | 10·188 | 7·59 | 0·97 | 317·81 | 2 53·41 | 3 33·22 |
| 20 | ... | 10·298 | 7·51 | 0·96 | 298·44 | 4 13·05 | 4 52·89 |
| 22 | ... | 10·407 | 7·43 | 0·94 | 279·06 | 5 32·73 | 6 12·58 |
| 24 | 160·10 | 10·515 | 7·35 | 0·93 | 259 67 | 6 52·43 | 7 32·30 |
| 26 | ... | 10·622 | 7·28 | 0 92 | 240·27 | 8 12 18 | 8 52·08 |

| | L—☊ | B. | A—L. | ß. | Ω. | E. |
|---|---|---|---|---|---|---|
| 51 | 303°42 | +22°90 | ... | +7°42 | 111°65 | 41°74 |
| 97 | 304·60 | 22·63 | ... | 6·98 | 111·49 | 41·70 |
| 32 | 305·78 | 22·35 | 40·02 | 6·54 | 111·32 | 41·65 |
| 56 | 306·97 | 22·06 | ... | 6·09 | 111·14 | 41·59 |
| 79 | 308·16 | 21·75 | ... | 5·64 | 110·95 | 41·51 |
| 00 | 309·37 | 21·43 | ... | 5·19 | 110·74 | 41·44 |
| 19 | 310·59 | 21·10 | 39·16 | 4·74 | 110·53 | 41·35 |
| 36 | 311·80 | 20·76 | ... | 4·28 | 110·31 | 41·25 |
| 52 | 313·02 | 20·40 | ... | 3·82 | 110·08 | 41·14 |
| 66 | 314·25 | 20·03 | ... | 3·35 | 109·84 | 41·02 |
| 79 | 315·48 | 19·65 | 38·27 | 2·88 | 109·59 | 40·91 |
| 90 | 316·72 | 19·26 | ... | 2·41 | 109·33 | 40·79 |
| 99 | 317·96 | 18·86 | ... | 1·94 | 109·05 | 40·66 |
| 06 | 319·20 | 18·45 | ... | 1·47 | 108·76 | 40·53 |
| 11 | 320·44 | 18·02 | 37·35 | 0·99 | 108·46 | 40·38 |
| 14 | 321·69 | 17·58 | ... | 0·51 | 108·15 | 40·24 |
| 15 | 322·94 | 17·13 | ... | +0·03 | 107·83 | 40·09 |
| 13 | 324·19 | 16·67 | ... | −0·46 | 107·49 | 39·93 |
| 10 | 325·45 | 16·20 | 36·43 | 0·94 | 107·14 | 39·77 |
| 04 | 326·71 | 15·72 | ... | 1·42 | 106·79 | 39·61 |
| 06 | 327·97 | 15·22 | ... | 1·90 | 106·42 | 39·44 |

| Greenwich Noon. 1903. | ☉ | Light Time. | Appar. Diam. | Defect of Illumination. | Central Meridian. | Passage of Zero Meridian. | |
|---|---|---|---|---|---|---|---|
| | ° | m | ″ | ″ | ° | h m | h m |
| July 28 | ... | 10·728 | 7·21 | 0·91 | 220·86 | 9 31·99 | 10 11·91 |
| 30 | ... | 10·834 | 7·14 | 0·90 | 201·44 | 10 51·84 | 11 31·77 |
| Aug. 1 | 164·38 | 10·939 | 7·07 | 0·89 | 182·01 | 12 11·71 | 12 51·66 |
| 3 | ... | 11·043 | 7·00 | 0·88 | 162·58 | 13 31·61 | 14 11·57 |
| 5 | ... | 11·146 | 6·93 | 0·87 | 143·14 | 14 51·53 | 15 31·50 |
| 7 | ... | 11·248 | 6·87 | 0·85 | 123·69 | 16 11·48 | 16 51·46 |
| 9 | 168·71 | 11·349 | 6·81 | 0·84 | 104·24 | 17 31·44 | 18 11·44 |
| 11 | ... | 11·450 | 6·75 | 0·83 | 84·78 | 18 51·45 | 19 31·45 |
| 13 | ... | 11·550 | 6·70 | 0·82 | 65·32 | 20 11·46 | 20 51·48 |
| 15 | ... | 11·649 | 6·64 | 0·81 | 45·85 | 21 31·51 | 22 11·54 |
| 17 | 173·11 | 11·747 | 6·58 | 0·80 | 26·38 | 22 51·58 | 23 31·62 |
| 19 | ... | 11·845 | 6·53 | 0·79 | 6·90 | ... | 0 11·67 |
| 21 | ... | 11·942 | 6·47 | 0·78 | 347·42 | 0 51·72 | 1 31·76 |
| 23 | ... | 12·038 | 6·42 | 0·77 | 327·94 | 2 11·80 | 2 51·84 |
| 25 | 177·57 | 12·132 | 6·37 | 0·76 | 308·46 | 3 31 89 | 4 11·94 |
| 27 | ... | 12·226 | 6·32 | 0·75 | 288·98 | 4 51·99 | 5 32·05 |
| 29 | ... | 12·320 | 6·27 | 0·73 | 269·49 | 6 12·11 | 6 52·18 |
| 31 | .. | 12·413 | 6·23 | 0·72 | 250·00 | 7 32·25 | 8 12·33 |
| Sept. 2 | 182·09 | 12·505 | 6·18 | 0 71 | 230·50 | 8 52·41 | 9 32·49 |
| 4 | ... | 12·596 | 6·14 | 0·70 | 211·00 | 10 12·58 | 10 52·67 |
| 6 | ... | 12·685 | 6·10 | 0·69 | 191·50 | 11 32·76 | 12 12·8 |
| 8 | ... | 12·774 | 6·05 | 0·68 | 172·00 | 12 52 93 | 13 33·02 |
| 10 | 186·67 | 12·863 | 6·01 | 0·67 | 152·50 | 14 13·11 | 14 53·19 |
| 12 | ... | 12·951 | 5·97 | 0 66 | 133·00 | 15 33·28 | 16 13·36 |
| 14 | ... | 13·038 | 5·93 | 0·65 | 113·50 | 16 53·45 | 17 33·55 |
| 16 | ... | 13·124 | 5·89 | 0·64 | 94·00 | 18 13·65 | 18 53·75 |
| 18 | 191·31 | 13·210 | 5·85 | 0·63 | 74·49 | 19 33·85 | 20 13·95 |
| 20 | ... | 13·295 | 5·81 | 0·62 | 54·98 | 20 54·06 | 21 34·16 |
| 22 | ... | 13·379 | 5·77 | 0·61 | 35·47 | 22 14·27 | 22 54·38 |
| 24 | ... | 13·463 | 5·74 | 0·60 | 15·96 | 23 34·49 | ... |
| 26 | 196·01 | 13·546 | 5·70 | 0·59 | 356·45 | 0 14·60 | 0 54·72 |
| 28 | ... | 13·628 | 5·67 | 0·58 | 336·93 | 1 34·85 | 2 14·98 |
| 30 | ... | 13·709 | 5·64 | 0·57 | 317·41 | 2 55·11 | 3 35·23 |
| Oct. 2 | ... | 13·790 | 5·61 | 0·56 | 297·89 | 4 15·36 | |

by Dr. Hermann Struve in the *Mémoires de l'Académie Imp. des Sciences de St-Pétersbourg*, 8ème série (*Math. Phys.*), vol. viii. No. 3.

The difference from the previous values is only nominal—

08 in R.A., −0°·05 in N.P.D. Struve's results in-
rrection for the precessional movement of *Mars'*
annual recession of the point O on its orbit being
lid not, however, note this point in time to introduce
on in the present ephemeris, but hope to do so in
s. The effect on L−O is only about 0°·04, which is
negligible.

es the position angle of the axis of *Mars*; L−O+180°
scension of the Earth referred to the plane of *Mars'*
d reckoned from O, the point of the vernal equinox
orthern hemisphere; Λ−O+180° the corresponding
· the Sun; B *B* the declinations of the Earth and Sun,
om the plane of *Mars'* equator; Q the position angle
est defect of illumination; *q* the amount of the same;
entric angle between the Earth and Sun.

−L is the angle between the meridians of *Mars* which
to the Earth and to the Sun; the point where an
he Sun should be looked for is distant $\frac{1}{2}(\Lambda-L)$ in
rom the centre of the disc, on the side towards the
nated limb, and is in areocentric latitude $\frac{1}{2}(B+B)$.

ıe areocentric longitude of the Sun referred to the
*ırs'* orbit, and reckoned from O (defined above). This
es at once the season on *Mars*; ☉ = 0° corresponds to
ın the Earth, ☉ = 30° to April 20, and so on.

rdance with more than one suggestion sent to me, I
d the value of the diameter of the planet at distance
9″·60 to 9″·30. This is the absolute diameter deduced
from a discussion of all the available material. It
be increased by the irradiation correction, but as that

I quote his own words as regards the method of observation :—

"These transits were got by setting the micrometer wire parallel to the direction of the axis as given in the ephemeris, and then noting the moment at which the snow-cap and the marking were equidistant from it.

"In order to determine whether the snow-cap itself were eccentrically placed with regard to the pole, I measured its position angle at various longitudes, the preliminary result of which shows its centre to be very close indeed to the pole—within less than half a degree distant. The result gives 0°·32 for its deviation in the direction of the meridian of 90°–270°, so that even this amount would delay, not hasten, the transit of the zero meridian. Consequently the position of the snow-cap will not explain the action, which would seem to be due to error in the epoch or the rotation period, or both."

With regard to this discordance I would point out that Mr. Marth in his last ephemeris altered his zero meridian to agree with Mr. Lowell's observations of 1894, so that we have only the effect of seven years' rotation to consider.

Now the adopted period can scarcely be in error by more than $0^s{\cdot}07$, or twenty-five seconds per annum ; this would only amount to three minutes in seven years.

From the method of Mr. Lowell's observations any error in the angle P would affect the time of transit ; so that if his discordance of $10^m$ is real, I think that the larger portion of it is probably due to error in the assumed position of *Mars'* axis.

M. Antoniadi has communicated to me some observations of the transit of the preceding edge of *Mare Acidalium* across the central meridian, from which he concludes that the error of my ephemeris was inappreciable. I have therefore not considered the evidence sufficiently strong to make any alteration in my constants ; but those who desire can adapt the ephemeris approximately to Mr. Lowell's observations by adding 2°·5 to the central meridian and subtracting $11^m$ from the transit of zero meridian. I may mention that the second decimal place in this last column has no pretence to accuracy, and is merely inserted to diminish cumulative error in the interpolation.

*Benvenue, 55 Ulundi Road, Blackheath, London, S.E.:*
1902 *June* 3.

## *Errata.*

*Erratum in Annual Report.*

, vol. lxii. *Monthly Notices*, line 8, *for* Roberts *read* Inn

*in Cape Double Star Results, Monthly Notices*, vol. lxii.

| | *For* | *Read* |
|---|---|---|
| $12^h\ 10^m$ | $334^m{\cdot}0$ | $344^m{\cdot}0$ |
| 13 53 | Remark 4 | Remark 6 |
| *h* 5069 | AC | AB, C |
| Sellors | $3^\circ{\cdot}35$ | $335^\circ$ |
| No. 3 | $-57^\circ$ | $-58^\circ$ |

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXII. SUPPLEMENTARY NUMBER, 1902. No. 9

*On the General Solution of Laplace's Equation and the Equation of Wave Motions, and on an undulatory explanation of Gravity.* By E. T. Whittaker, M.A.

## 1. *Laplace's Equation.*

The first part of this communication is concerned with the well-known equation which was first introduced in Laplace's memoir on the ring of *Saturn*, and which is now of such importance in mathematical physics. The general solution has not hitherto been found in a finite form: we shall show that it is given in a finite form by the following result:

*The general solution of Laplace's equation*

$$\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial y^2}+\frac{\partial^2 V}{\partial z^2}=0$$

*is*

$$V=\int_0^{2\pi} f(x\cos v+y\sin v+iz,\ v)\,dv,$$

*where $f$ is an arbitrary function of the two arguments $x\cos v+y\sin v+iz$ and $v$.*

To establish this, let $V(x, y, z)$ be any solution (single-valued or many-valued) of Laplace's equation. Since the differential equation is unaffected by a change of origin, and since any function of the two arguments $(x\cos v+y\sin v+iz)$ and $v$ is also a function of the arguments $(x'\cos v+y'\sin v+iz')$ and $v$, where $(x', y', z')$ are the coordinates of the point $(x, y, z)$ referred to parallel axes through any other origin, it clearly will not affect the generality of the proof if any particular point be taken as origin; we shall therefore suppose that the origin is taken at some point at which some branch of the function $V(x, y, z)$ is

ace's equation is the equation satisfied by the com-
y field of force due to gravitating bodies, this result
:planation of the propagation of gravitation. For
at it is possible to analyse the field of force due to
body, by a "spectrum analysis" as it were, into an
er of constituent fields; and although the whole
loes not vary with the time, yet each of the con-
is of an undulatory character, *i.e.* the disturbance
reproduces itself after the lapse of any time at
whose distance is proportional to the elapsed time.
t assimilates the propagation of gravitation to that
the undulatory phenomena just described, in which
ector is a gravitational force perpendicular to the
ıay be compared with those made familiar by the
ic theory of light, in which the varying vectors
tric and magnetic forces parallel to the wave-front.
e in other respects of the same type in the two
seems probable that an identical property of the
es their transmission through space. This undula-
of gravity would require that gravity should be
th a finite velocity, which, however, need not be the
of light, and may be enormously greater.

this investigation does not explain the *cause* of
that is done is to show that the propagation
f forces which vary as the inverse square of the
not require for its explanation any other property of
ıan one which has long been known and accepted.

Now, for $t = -\theta_3$

$$s = s_1, \quad \frac{d^2s}{dt^2} = \frac{2}{\sqrt{s_1}} - \frac{2}{a},$$

for $t = 0$

$$s = s_2, \quad \frac{d^2s_2}{dt^2} = \frac{2}{\sqrt{s_2}} - \frac{2}{a},$$

for $t = \theta_1$

$$s = s_3, \quad \frac{d^2s_3}{dt^2} = \frac{2}{\sqrt{s_3}} - \frac{2}{a}.$$

Hence

$$s_1 = a_0 - \theta_3 a_1 + \theta_3^2 a_2 - \theta_3^3 a_3 + \theta_3^4 a_4,$$

$$s_2 = a_0,$$

$$s_3 = a_0 + \theta_1 a_1 + \theta_1^2 a_2 + \theta_1^3 a_3 + \theta_1^4 a_4,$$

$$\frac{2}{\sqrt{s_1}} - \frac{2}{a} = 2a_2 - 6\theta_3 a_3 + 12\theta_3^2 a_4,$$

$$\frac{2}{\sqrt{s_2}} - \frac{2}{a} = 2a_2,$$

$$\frac{2}{\sqrt{s_3}} - \frac{2}{a} = 2a_2 + 6\theta_1 a_1 + 12\theta_1^2 a_4.$$

Eliminating the five constants $a_0$, $a_1$, $a_2$, $a_3$, $a_4$ from these six equations, we get a single equation of the form

$$\left.\begin{aligned} &\frac{\theta_1\theta_2\theta_3}{a} = 2\left(\frac{\theta_1\mu_1}{r_1} + \frac{\theta_2\mu_2}{r_2} + \frac{\theta_3\mu_3}{r_3}\right) = (\theta_1 r_1^2 - \theta_2 r_2^2 + \theta_3 r_3^2) \\ &\text{where} \\ &\mu_1 = \frac{1}{12}(\theta_2\theta_3 - \theta_1^2), \ \mu_2 = \frac{1}{12}(\theta_1\theta_3 + \theta_2^2), \ \mu_3 = \frac{1}{12}(\theta_1\theta_2 - \theta_3^2) \end{aligned}\right\} \quad (1)$$

This is the required equation. A less exact formula is given by Radau in *Bulletin Astronomique*, tome ii. p. 11.

§ 2. For the purpose of testing the above expression (1) I have chosen the *Ceres* example treated by Gauss, Oppolzer, and Gibbs, the interval of extreme observations being about 260 days.

| | | |
|---|---|---|
| $\log \theta_1 = 0{\cdot}335852$ | $\log \mu_1 = 9{\cdot}669211$ | $\log r_1 = 0{\cdot}428279$ |
| $\log \theta_2 = 0{\cdot}650362$ | $\log \mu_2 = 0{\cdot}318372$ | $\log r_2 = 0{\cdot}413281$ |
| $\log \theta_3 = 0{\cdot}362407$ | $\log \mu_3 = 9{\cdot}562392$ | $\log r_3 = 0{\cdot}406200$ |

The computation by (1) gives us $\log a = 0{\cdot}442438$,

while Oppolzer gives $\log a = 0{\cdot}442463$.

The coincidence is fairly good, if we consider the long interval of time between two observations.

special case of parabolical orbits (1) becomes

$$-\frac{2\mu_1}{r_1^3}\Big)-\theta_2 r_2^2\Big(1+\frac{2\mu_2}{r_2^3}\Big)+\theta_3 r_3^2\Big(1-\frac{2\mu_3}{r_3^3}\Big)=0 \qquad (2)$$

tween three heliocentric distances and the time.
, $E_2$, $E_3$ be the corresponding excentric anomalies,

$$-E_2)-(r_2-a)\sin(E_3-E_1)+(r_3-a)\sin(E_2-E_1)$$
$$=0,$$

be written in the form

$$a+\frac{2\mu_1}{ar_1}\Big)-(r_2-a)\theta_2\Big(r_2+a-\frac{2\mu_2}{ar_2}\Big)$$
$$+(r_3-a)\theta_3\Big(r_3+a+\frac{2\mu_3}{ar_3}\Big)=0.$$

paring the two above equations, we see that

$$-E_2) \qquad \sin(E_3-E_1) \qquad \sin(E_2-E_1)$$

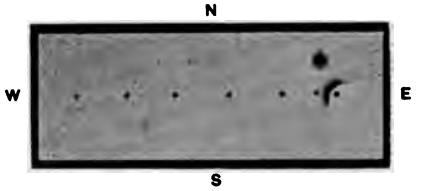
y proportional to

$$+\frac{2\mu_1}{ar_1}\Big) \qquad \theta_2\Big(r_2+a-\frac{2\mu_2}{ar_2}\Big) \qquad \theta_3\Big(r_3+a+\frac{2\mu_3}{ar_3}\Big)=0.$$

# ROYAL OBSERVATORY, GREENWICH.

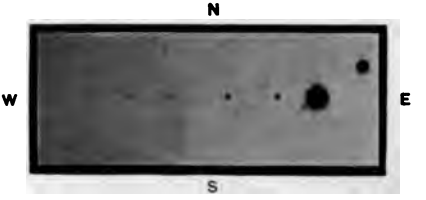
PHOTOGRAPHS OF NEPTUNE AND SATELLITE TAKEN WITH THE THOMPSON 26-INCH PHOTOGRAPHIC REFRACTOR.

Enlarged five times. Scale 1 mm. = 6″.

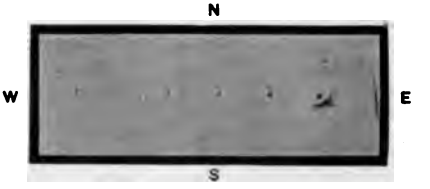



1902 February 11. *Neptune* to the right under the occulting shutter within the halo of the secondary spectrum. The satellite is to the left of *Neptune* (position-angle 277°). The other images are with five exposures of four seconds each on *Neptune* for orientation—the telescope being displaced in R.A. between the exposures.

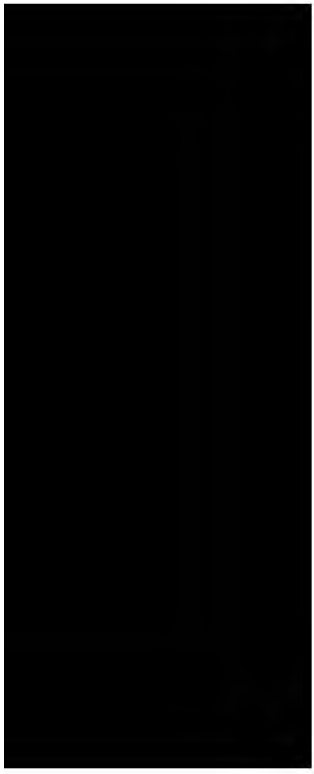
The star north-west of *Neptune* is B.D. +22° 1138. Mag. 9·3.




1902 February 12. *Neptune* not occulted. Position-angle of satellite 235°. The other images are with exposures of $5^s$, $4^s$, $3^s$ and $5^s$ on *Neptune* (starting from *Neptune*).




1902 March 3. *Neptune* occulted. Position-angle of satellite 125°. The other images are with exposures of $5^s$, $3^s$, $2^s$, $2^s$ and $3^s$ on *Neptune*. It will be seen that the image of the satellite with $20^m$ exposure is nearly equivalent to that of *Neptune* with $3^s$ exposure.



addition to the long-exposure photograph of the satellite, a of number short-exposure images of *Neptune*.

On some of the photographs the duration of the supplementary exposures was adjusted so as to give images of the planet of the same size and density as the image of the satellite. Incidentally these determine the length of exposure given with the occulting shutter, but they are of photometric importance as showing that the satellite requires an exposure 420 times that of *Neptune* to give an equal photographic image, which, on the assumption that the photographic effect is the same for the same total amount of light, makes the satellite $6^{m}\cdot55$ fainter than *Neptune*.

The following table gives the details of these observations :—

| No of Plate. | Date. | Exposure of Satellite. | Exposure of Planet giving an Equal Image. | Ratio. | Log. | Diff. of Magnitude. |
|---|---|---|---|---|---|---|
| | 1902. | m | s | | | |
| 1106 | Feb. 12 | 20 | 2·9 | 414 | 2·617 | 6·54 |
| 1115 | Feb. 28 | 21 | 2·7 | 467 | ·669 | 6·67 |
| 1119 | Mar. 3 | 20 | 3·0 | 400 | ·602 | 6·51 |
| 1120 | Mar. 3 | 15 | 2·5 | 360 | ·556 | 6·39 |
| | | 20 | 3·0 | 400 | ·602 | 6·51 |
| 1121 | Mar. 3 | 20 | 2·5 | 480 | ·681 | 6·70 |
| | | | Mean | 420 | 2·621 | 6·55 |

The photographs were measured in a position micrometer in direct and reversed positions by Mr. Dyson, Mr. Davidson, and Mr. Melotte, and the results obtained by each measurer are given in order to show the degree of accordance obtained.

Corrections have not been applied separately to the distances or angles for refraction. These will in all cases be less than $0''\cdot01$. The mean effects of refraction and aberration have, however, been included in the adopted value of the scale, as these corrections affect the mean distance of the satellite slightly, and would directly affect the mass of *Neptune* determined from these observations.

The value of $1^{rev}$ of the screw of the measuring micrometer was determined in terms of a réseau interval of one of Gautier's réseaux used in photographic work with the Thompson and Astrographic equatorials. For photographs with the Thompson equatorial cleared of the effect of differential refraction and aberration the réseau interval $= 150''\cdot89$. The correction for differential refraction on these photographs of *Neptune* varies from $+''\cdot042$ to $+''\cdot072$, and for differental aberration from $+0''\cdot006$ to $+''\cdot010$. A mean total correction of $+''\cdot07$ has been adopted, giving the réseau interval $= 150''\cdot96$, and has been used for all the photographs.

The tabular positions were computed from the data given in the *Connaissance des Temps*, based on M. H. Struve's elements, the eccentricity of the orbit being neglected owing to the uncertainty as to the present position of the periastron.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | occulted. |
| 50 | −0·37 | 12·65 | 12·81 | 12·83 | 12·76 | 13 09 | +0·33 | 20½ | | |
| 13 | +1·29 | 11·20 | 11·11 | 10·98 | 11·10 | 11·49 | +0·39 | 25 | | |
| 15 | +0·86 | 11·21 | 11·44 | 11·38 | 11·34 | 11·40 | +0·06 | 20 | Neptune occulted. | not |
| 12 | +1·84 | 14·21 | 14·29 | 14·16 | 14·22 | 14·48 | +0·26 | 20½ | | |
| 16 | +0·92 | 14·60 | 14·76 | 14·71 | 14·69 | 14·61 | −0·08 | 20 | Neptune occulted. | not |
| 10 | +0·69 | 15·46 | 15·40 | 15·07 | 15·31 | 15·43 | +0·12 | 21 | | |
| 16 | +1·53 | 14·51 | 14·75 | 14·51 | 14·59 | 15·32 | −0·27 | 21 | Neptune not occulted. Windy. | |
| 30 | +1·35 | 10·63 | 10·65 | 10·48 | 10·59 | 10·75 | +0·16 | 30 | | |
| 17 | +2·45 | 10·80 | 10·63 | 10·86 | 10·76 | 10·75 | −0·01 | 34 | Neptune occulted. | not |
| 18 | +1·51 | 15·11 | 15·35 | 15·27 | 15·24 | 15·18 | −0·06 | 25 | | |
| 48 | +0·02 | 15·98 | 16·25 | 16·10 | 16·11 | 15·90 | −0·21 | 25 | | |
| 20 | +0·59 | 11·21 | 10·86 | 10·85 | 10·97 | 10·86 | −0·11 | 6 | | |
| 25 | +1·63 | 10·79 | 10·98 | 11·08 | 10·95 | 10·91 | −0·04 | 10 | | |

| Date. 1902 | | | | Position-angle. | | | | | | Distance. | | | | | | Exposure. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | D. | C.D. | P.M. | Mean. | Tab. | T−O. | D. | C.D. | P.M. | Mean. | Tab. | T−O. | | |
| | d | h | m | s | ° | ° | ° | ° | ° | ″ | ″ | ″ | ″ | ″ | ″ | m | |
| Feb. | 11 | 7 | 9 | 16 | 277·08 | 276·23 | 276·30 | 276·54 | 276·77 | +0·23 | 15·86 | 15·89 | 15·87 | 15·87 | 15·83 | −0·04 | 20 | |
| | 11 | 7 | 37 | 24 | 274·13 | 274·40 | 274·32 | 274·28 | 275·92 | +1·64 | 15·67 | 15·83 | 15·95 | 15·82 | 15·91 | +0·09 | 20 | |
| | 11 | 8 | 11 | 9 | 274·22 | 274·07 | 274·00 | 274·10 | 274·90 | +0·80 | 16·10 | 15·99 | 15·84 | 15·98 | 16·01 | +0·03 | 20½ | |
| | 11 | 8 | 39 | 21 | 273·75 | 273·85 | 273·72 | 273·77 | 274·08 | +0·31 | 16·09 | 16·06 | 15·95 | 16·03 | 16·08 | +0·05 | 20 | |
| | 12 | 7 | 51 | 5 | 233·48 | 233·12 | 232·25 | 232·95 | 233·50 | +0·55 | 14·57 | 14·71 | 14·99 | 14·76 | 14·65 | −0·11 | 20 | |
| | 13 | 8 | 13 | 25 | 151·67 | 151·43 | 152·95 | 152·02 | 153·93 | +1·91 | 10·92 | 10·53 | 10·54 | 10·66 | 10·94 | +0·28 | 30 | Satellite badly defined. |
| | 15 | 8 | 2 | 34 | 49·11 | 49·18 | 48·80 | 49·03 | 49·87 | +0·84 | 14·18 | 13·89 | 13·88 | 13·98 | 14·22 | +0·24 | 30 | |
| | 15 | 9 | 3 | 39 | 47·00 | 46·06 | 49·04 | 47·37 | 47·55 | +0·18 | 13·73 | 13·56 | 13·92 | 13·74 | 13·95 | +0·21 | 20 | Satellite badly defined. |
| | 16 | 7 | 5 | 31 | 330·15 | 329·62 | 329·92 | 329·90 | 332·68 | +2·78 | 11·14 | 10·59 | 10·78 | 10·84 | 10·96 | +0·12 | 20 | Satellite badly defined. |
| | 16 | 8 | 19 | 44 | 326·27 | 325·88 | 326·78 | 326·31 | 328·08 | +1·77 | 11·16 | 11·25 | 10·91 | 11·11 | 11·14 | +0·03 | 20½ | |
| | 28 | 7 | 59 | 1 | 309·30 | 309·10 | 308·96 | 309·12 | 309·68 | +0·56 | 12·10 | 12·37 | 12·33 | 12·27 | 12·23 | −0·04 | 21 | |
| | 28 | 8 | 48 | 39 | 308·08 | 307·13 | 308·56 | 307·92 | 307·25 | −0·67 | 11·97 | 12·15 | 12·00 | 12·04 | 12·44 | +0·40 | 20 | |
| | 28 | 9 | 26 | 28 | 305·73 | 304·88 | 305·43 | 305·35 | 305·45 | +0·10 | 12·47 | 12·58 | 12·32 | 12·46 | 12·60 | +0·14 | 20 | |
| Mar. | 1 | 8 | 27 | 0 | 258·13 | 257·30 | 257·88 | 257·77 | 259·57 | +1·80 | 16·60 | 16·33 | 16·28 | 16·40 | 16·55 | +0·15 | 21 | |
| | 3 | 7 | 19 | 54 | 125·72 | 126·46 | 126·45 | 126·21 | 127·27 | +1·06 | 12·59 | 12·58 | 12·60 | 12·59 | 12·41 | −0·18 | 20 | |
| | 3 | 8 | 5 | 20 | 124·65 | 124·08 | 124·75 | 124·49 | 125·12 | +0·63 | 12·59 | 12·67 | 12·61 | 12·62 | 12·61 | −0·01 | 15 | |
| | 3 | 8 | 29 | 1 | 122·57 | 123·22 | 123·03 | 122·94 | 124·02 | +1·08 | 12·58 | 12·63 | 12·59 | 12·60 | 12·71 | +0·11 | 20 | |
| | 3 | 9 | 6 | 0 | 121·20 | 121·29 | 121·56 | 121·35 | 122·33 | +0·98 | 12·53 | 12·73 | 12·59 | 12·62 | 12·87 | +0·25 | 20 | |
| | 3 | 9 | 34 | 45 | 121·12 | 121·04 | 120·74 | 120·97 | 121·05 | +0·08 | 13·12 | 13·08 | 12·90 | 13·03 | 13·00 | −0·03 | 20 | |



| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 89 | +0·74 | 15ᵐ11ˢ | 15ᵐ28ˢ | 15ᵐ67ˢ | 15ᵐ35ˢ | 15ᵐ51ˢ | +0·16 | 10 | | |
| 07 | +1·13 | 14·73 | 15·01 | 14·94 | 14·89 | 14·72 | −0·17 | 12 | | |
| 20 | +0·12 | 14·62 | 14·74 | 14·69 | 14·68 | 14·82 | +0·14 | 12 | | |
| 07 | +1·45 | 14·72 | 14·73 | 14·46 | 14·64 | 14·97 | +0·33 | 12 | | |
| 13 | +0·59 | 14·86 | 14·95 | 14·80 | 14·87 | 15·10 | +0·23 | 12 | | |
| 09 | +2·44 | 15·04 | 15·08 | 15·12 | 15·08 | 15·26 | +0·18 | 20½ | | |
| 08 | +0·41 | 14·75 | 14·85 | 14·87 | 14·82 | 14·95 | +0·13 | 20 | | |
| 05 | +0·29 | 14·97 | 14·92 | 15·06 | 14·98 | 14·84 | −0·14 | 20 | | |
| 14 | −0·78 | 14·77 | 15·10 | 15·05 | 14·97 | 15·25 | +0·28 | 12 | Satellite faint. | very |
| 07 | +2·17 | 15·67 | 15·60 | 15·52 | 15·60 | 15·31 | −0·29 | 12 | Satellite faint. | very |
| 25 | +0·84 | 15·54 | 15·53 | 15·77 | 15·61 | 15·40 | −0·21 | 20 | | |
| 15 | +0·83 | 15·66 | 15·55 | 15·22 | 15·48 | 15·47 | −0·01 | 20 | | |
| 50 | +0·36 | 13·47 | 13·31 | 13·22 | 13·33 | 13·57 | +0·24 | 20 | | |
| 76 | +0·59 | 11·07 | 10·98 | 11·03 | 11·03 | 11·26 | +0·23 | 15 | | |
| 31 | +1·64 | 11·20 | 11·21 | 11·10 | 11·17 | 11·35 | +0·18 | 15 | | |

## *Observation of Saturn on 1902 July 17, made at Perth Observatory, Western Australia.*

(*Communicated by W. Ernest Cooke, M.A., Government Astronomer.*)

As astronomers have been asked for observations of *Saturn* about July 17, I beg to report as follows :—

July 17 between $0^h$ and $1^h$ G.M.T. Definition remarkably good. Instrument, 10-inch guide telescope of astrograph. Power of eyepiece not measured but estimated about 600. The division could be distinctly traced across the planet, with no sign of a break.

This was the only chance we had, the weather on each side being cloudy or definition bad.

The north polar regions were very dark.

1902 *July* 21.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 3 | 19 | 50 | 24·22 | −0·31 | −9·2211 | 94 | 46 (44·6) | 13·5 | 0·8626 (*a*) |
| 14 | 5 | 19 | 53 | 13·34 | −0·36 | −9·2791 | 95 | 3 31·6 | 13·8 | 0·8628 (*b*) |
| 7 | 12 | 19 | 56 | 1·66 | −0·37 | −9·2761 | 95 | 22 51·3 | 14·2 | 0·8641 (*c*) |

*Observer's Remarks.*

n this night are only approximate; the resulting N.P.D. has, therefore, been ar condensation of about magnitude 12. The comparison star is of the 10th bout the 12th magnitude. The magnitude of the comparison star is 11.

*Places of the Comparison Stars.*

| | Authority. |
|---|---|
| observations Radcliffe Transit Circle, 1899 | |
| bservations R.A. and three observations N.P.D. Radcliffe Transit Circle, 1899. | |
| observations Radcliffe Transit Circle, 1899. | |

ed value of the Sun's mean horizontal parallax is 8″·85, and the *nische Nachrichten*, No. 3554.

: Mr. W. H. Robinson.

*Old Cape Records of Comets.* By R. T. A. Innes.

In arranging the old records of the Cape Observatory I came across a letter giving some records of comets seen from the Cape in the seventeenth century. With Sir David Gill's sanction I transmit a copy of it. The year of the letter is not given. It was probably written in 1858 to 1860, but the exact date is immaterial.

February 28.

My Dear Sir,—In my rapid progress through the old journals my eye has been caught by the notices of which I annex the translations. I may have passed over some others from the impossibility of attempting to do more than skim, but if there are any years in particular during which a moré particular examination would [be] interesting to you, pray let me know the years, and I shall not fail to look more closely.—I am, &c., (Signed) D. Moolin.

T. Maclear, Esq.

1664 December 15.—"About midnight, with a sky partially clouded, we all here saw a star with a darkish ray or tail, which it is said showed itself much more clearly and distinctly about 3 o'clock when it was near day; the star rose in the East and the tail pointed directly North."

1686, Monday, August 12.—"This night appeared in the 5th house of the heavens, at one o'clock, in the horizon, *a comet*, corresponding in longitude (!) with *Saturn* and *Venus*, on the left shoulder of the *Hare*. S. Lat. 18° 4′, Long. 80° 8′. The tail extended right East and West to the length of 35 Celestial Degrees, in *Gemini*."

1689 November 24.—"A star with a tail was seen in the [MS. defaced]."

1689 November 25.—"This morning about 4 o'clock the said tailed star was again seen, which soon after disappeared as the Sun rose."

1689 December 9.—"This morning at 3 o'clock the tailed star showed itself very distinctly, the tail was more than 4 degrees long."

1689 December 24.—"The tailed star no longer seen."

*ce of a Star near the Variable RU Herculis.*
tion to former paper.) By F. A. Bellamy.

, Fr. Hagen has kindly drawn attention to a
tween his observation and the position of star
in my paper (*Monthly Notices*, lxii. p. 75). Upon
e cause was found to be in the transcription from
asure sheets to the computation forms preliminary
f measured coordinates to R.A. and Dec. : the
pposite star No. 19 should read thus :—

8·3363 5·6320 $6^m$ $16^s.76$ 23′ 7″·4

ns have been examined for the other stars but no
ere found.

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*Formula for the Wave-Lengths of Nebular Lines.*
By W. H. Wright.

(*Communicated by the Secretaries.*)

TABLE I.

| $n$ | $\lambda$ computed. | $\lambda$ in nebulæ. | |
|---|---|---|---|
| 3 ... ... ... | 7637·0 | not observed. | |
| 4 ... ... ... | 4363·6 | 4363·3 | Used to deduce the formula. |
| 5 ... ... ... | 3967·6 | 3967·6 | |
| 6 ... ... ... | 3868·9 | 3868·9 | |
| 7 ... ... ... | 41·6 | not observed. | |
| 8 ... ... ... | 36·1 | 3836* (Campbell). | |
| 9 ... ... ... | 37·9 | not observed. | |
| 10 ... ... ... | 41·9 | 3842 (Huggins). | |
| 11 ... ... ... | 46·3 | not observed. | |
| 12 ... ... ... | 50·6 | not observed. | |
| 13 ... ... ... | 54·4 | 3854 (Huggins). | |

By assuming $n = 11{\cdot}5$ and $14{\cdot}5$, additional approximate coincidences are secured with two of the lines observed by Huggins.

Let us examine somewhat critically the identities assumed by Mr. Love, as given in column three of the above table. As he points out, it is hardly probable that a line at $\lambda$ 7637 would be observed in a nebular spectrum, supposing it were present. The agreement of the next three wave-lengths should follow as a matter of necessity, as they were used in computing the constants of the formula. Owing, however, to some slight numerical error, there is a discrepancy of 0·3 tenth-metre between the observed and computed values of the line $\lambda$ 4363. Just what effect the correction of this error would have on the computed wave-lengths I have not determined. It is probable that the change would not amount in any case to more than one unit.

Passing for a moment the identification of the value $n = 8$, we come to the lines observed by Huggins. With regard to them it may be said that they are only a few of a group reported by that observer as existing in this region of the spectrum. The entire group is as follows : $\lambda\lambda$ 3896, 3887, 3878, 3870, 3859, 3854, 3848, 3842, 3832 and 3825. Under the circumstances some apparent coincidences are to be expected. Attention should moreover be called to the fact that there appears to be a systematic difference between Huggins's determinations and my own (from which the constants of Mr. Love's formula were computed) amounting to about +2·5 tenth-metres (W—H). This difference was determined from the three lines $\lambda\lambda$ 5007, 4959, and 3727, and is partly to be accounted for by the difference between the Angström and Rowland scales, amounting

* The wave-length published by Campbell is $\lambda$ 3835. The wave-length given in the table is the one assumed by Mr. Love in his discussion.

to about 0·8 tenth-metre. The reason for the particular lines is that they are the only lines oth Sir William Huggins and myself concerning ions could not be made as to wave-length. The sured by both observers were by each assumed hydrogen, and cannot therefore be used for the . Assuming that the difference +2·5 affects the nder discussion, the coincidences in Table I. are ere is, however, a line in the group at λ 3848, and orrection we have a coincidence with the value nding to $n = 12$, a fact which indicates, perhaps, thing else, the likelihood of occasional coincidences his sort. It should further be stated that the mentioned was observed only on the much negative secured by Sir William and Lady s photograph was taken fourteen years ago, and, lications were of remarkable interest, they have confirmed, though attempts were made by several ably Keeler, Campbell, and Huggins himself—to rvations.

incidence, then, to be taken seriously is that of ine has been identified by Campbell and others as and there is little reason to doubt that the correct. It is one of a series of lines in the *Orion* nebula, the members of which decrease ensity towards the violet, and agree, within the ational error, with the lines of the well-known . In Table II. are the wave-lengths as measured

finds it "much easier to believe some of Campbell's identifications wrong than to believe that his measurements are incorrect by three and four tenth-metres." Campbell's measurements seem to the writer to constitute a proof that the ultra-violet hydrogen series has been observed in the *Orion* nebula as far as $H_\kappa$, and that the line $\lambda$ 3835 is due to hydrogen. But, however that may be, evidence is not lacking that the line does not belong to a series including $\lambda\lambda$ 4363, 3968, and 3869. The line in question does not appear to vary in intensity in a regular manner with the latter lines, unless indeed the relation be an inverse one. The line $\lambda$ 3835 and those in Table II. to the violet of it have been observed only in the *Orion* nebula, an object in which the hydrogen lines are unusually bright, and the three lines mentioned comparatively faint. It is in the planetary nebulæ, in which the line $\lambda$ 3835 is too faint for observation, that the three lines taken by Mr. Love as the basis of his series are bright.

In view of the above facts the writer considers that there is not a single coincidence between computed and observed wave-lengths upon which the proposed formula can be considered to rest.

The writer considers it very doubtful whether $\lambda$ 4363 is emitted under the same conditions as $\lambda\lambda$ 3968 and 3869. The latter lines are of about the same intensity in a number of different nebulæ,* but the intensity of $\lambda$ 4363 appears to vary relatively to them more than can be accounted for by instrumental considerations. So far as the three corresponding *Nova* bands being characterised by an identity of structure is concerned, the observations made at the Lick Observatory show the structure of all the brighter lines to be pretty much the same.

*Lick Observatory:* 1902 *August.*

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## *Explanation of Use of Tables of* $\frac{1}{2}(\theta + \cos\theta)$.

By W. Steadman Aldis, M.A.

The equations connecting the eccentric, true, and mean anomalies, and radius vector in an elliptic orbit are

$$(1) \qquad m = u - e \sin u ;$$

$$(2) \qquad \tan\frac{v}{2} = \sqrt{\frac{1+e}{1-e}}\tan\frac{u}{2} ;$$

$$(3) \qquad r = a(1 - e\cos u).$$

* Lick Observatory Bulletin, No. 19.

$= \sin \phi$, (1) becomes

$= u - \sin \phi \sin u$

$= \frac{1}{2}\{\phi + u + \cos(\phi + u)\} - \frac{1}{2}\{\phi - u + \cos(\phi - u)\}$

$= C(\phi + u) - C(\phi - u)$

$\frac{1}{2}(\theta + \cos \theta)$.

anying tables give the value of $C(\theta)$ in seconds
te of angle between $-90°$ and $+90°$.
beyond these limits it is easily shown that

$$C(180° - \theta) = N - C(\theta)$$
$$C(-180° + \theta) = -N - C(-\theta)$$
$$C(180° + \theta) = N - C(-\theta)$$

000 = number of seconds in a right angle.

*Examples of Use.*

*atory*, 1895 March, gave elements of Barnard's

och 1895, Feb. 9·0, Berlin Mean Time.

$8'$, $\phi = 35°\ 43'$, $\mu = 656''$, $\log a = 0{\cdot}4886$.

values of the mean anomaly at midnight on the
cording to the subjoined table :

Take $u = 12'$; from the tables.

$C(\phi+u) = C(35^\circ\ 55') = 148173''{\cdot}9463$ diff. for $1'$ in $u = 12''{\cdot}3982$

$C(\phi-u) = C(35^\circ\ 31') = 147874''{\cdot}2652$ " " in $u$ downwards $= 12''{\cdot}5754$

difference $= 299''{\cdot}6811$

This is too small by $20''{\cdot}3189$, and as an increase of $1'$ in $u$ would increase this on the whole by $24{\cdot}9736$, the required increase must be $\frac{20{\cdot}3189}{24{\cdot}9736} \times 60'' = 48''{\cdot}8$.

Thus $u = 12'\ 48''{\cdot}8$.

Take midnight, May 26; neglecting the sign,

$$m = 5584'' = C(\phi+u) - C(\phi-u).$$

A first approximation, by difference opposite $35^\circ\ 43'$, gives

$$u = \frac{5584}{2 \times 12{\cdot}48} \text{ minutes} = 3^\circ\ 42' \text{ about.}$$

With this value

$C(\phi+u) = C(39^\circ\ 25') = 150624''{\cdot}8251$, diff. for $60'' = 10''{\cdot}9480$

$C(\phi-u) = C(32^\circ\ 1') = 145075''{\cdot}3368$ " " downwards $= 14''{\cdot}0987$

difference $= 5549''{\cdot}4883$

This is too small by $34''{\cdot}5117$, and $u$ therefore must be increased by $\frac{34{\cdot}5117}{25{\cdot}0467} \times 60'' = 1'\ 22''{\cdot}7$.

Thus $u = 3^\circ\ 43'\ 22''{\cdot}7$.

When $u$ is found (2) will give $v$. Equation (3) can be modified thus:

$$r = a(1-e\cos u)$$

or

$$r = a(1-\sin\phi\cos u)$$

$$= a\left\{\frac{1-\sin\overline{\phi+u}}{2} + \frac{1-\sin\overline{\phi-u}}{2}\right\}$$

$$= a\left\{\left(\frac{dC}{d\theta}\right)_{\theta=\phi+u} + \left(\frac{dC}{d\theta}\right)_{\theta=\phi-u}\right\}$$

Now the difference between two consecutive values of $C(\theta)$ in the tables, divided by 60, is clearly a very close approximation to the value of $\left(\frac{dC}{d\theta}\right)$ for a value of $\theta$ halfway between the two consecutive arguments.

In the last example

$$\phi = 35^\circ\ 43',$$
$$u = 3^\circ\ 43'\ 22''{\cdot}7$$
$$\phi+u = 39^\circ\ 26'\ 22''{\cdot}7, \quad \phi-u = 31^\circ\ 59'\ 37''{\cdot}3$$

From the tables $\left(\frac{dC}{d\theta}\right)_{\theta=39^\circ\ 26'\ 30''} = \frac{10{\cdot}9412}{60} = {\cdot}18235$

e for 39° 25′ 30″ is ·18247. Thus the value of

$\theta = 39°\ 26'\ 22''{\cdot}7$ is ·18236 very nearly.

$\theta = 31°\ 59'\ 37''{\cdot}3$, $\frac{dC}{d\theta} = {\cdot}23509$

$r = a \times {\cdot}20878$

ate within the limits of the data.

an example an orbit of large eccentricity and also mean anomaly, that of Halley's Comet, Epoch 1910 *pedia Britannica*)

Period 76·085 yrs., $e = {\cdot}961733$, T = May 26·83.

26·83, 1900, the mean anomaly of the comet was

$\frac{360 \times 60 \times 60}{76{\cdot}085}$ seconds = 170335″·8 nearly

= 31° 48′ 55″·8 nearly

$u = n - e \sin u$

$v = m + e \sin m$. 1st approximation ... (A)

$= m + (e + e^2 \cos m) \sin m$

$= m + e' \sin m$. 2nd approximation ... (B)

approximation

Take as a trial value $u = 60^\circ\ 52'$

$$\phi = 74\ \ 6$$

$$C(\phi+u) = C(180^\circ-45^\circ\ 2') = N-C(45^\circ\ 2')$$

$$C(\phi-u) = C(13^\circ\ 14')$$

$$C(45^\circ\ 2') = 153943''{\cdot}1829 \text{ diff. for } 60'' = 8''{\cdot}7713$$

$$C(13\ 14) = 124213{\cdot}8138 \quad \text{,,} \quad \text{,,} \quad 23{\cdot}1283$$

$$\text{sum} = 278156{\cdot}9967$$

$$324000{\cdot}$$

$$m = 45843{\cdot}0033$$

The deficiency in the value of $m$ is $134492''{\cdot}8$. The increase in the value of $m$ for a change of $1'$ in $u$ is at the present point about $8''{\cdot}8+23''$, or roughly $32''$. If this continued uniform, an addition of $\frac{134492{\cdot}8}{32}$ minutes would have to be made to $u$, or of $70^\circ\ 31'$.

This would make

$$u = 130^\circ\ 55', \quad \phi+u = 205^\circ\ 1' = 180^\circ+25^\circ{\cdot}1$$

$$\phi-u = -56^\circ\ 49'$$

and at this point a change of $1'$ in $u$ would make a total change of $42''{\cdot}7+55''{\cdot}1$, or nearly $98''$, in $m$; nearly three times the amount at starting. If we assume an average change of double the original value of the increment, the required change in $u$ will be $35^\circ$. This gives $u = 95^\circ\ 52'$

$$\therefore (\phi+u) = 169^\circ\ 58' = 180-10^\circ\ 2'$$

$$(\phi-u) = -21^\circ\ 46'.$$

Hence $m = N-C(10^\circ\ 2')-C(-21^\circ\ 46')$.

Now

$$C(10^\circ\ 2') = 119615''{\cdot}1541, \text{ diff. for } 1' = 24''{\cdot}7691$$

$$C(-21\ 46) = 56599{\cdot}2405 \quad \text{,,} \quad \text{,,} \quad 41{\cdot}1289$$

$$176214{\cdot}3946$$

$$324000{\cdot}$$

Thus $m = 147785{\cdot}6054$

The deficiency is now $22550''$, and the change in $m$ for an increase of $60''$ in $u$ is about $66''$. This change increases as $u$ increases, and if it be assumed on an average to be about $70''$, an increment to $u$ of about $5^\circ$ is needed.

$u = 100^\circ\ 52'$

$m = \mathrm{N} - \mathrm{C}\,(5^\circ\ 2') - \mathrm{C}\,(-26^\circ\ 46')$

C $(5^\circ\ 2') = 111794''{\cdot}7$, diff. for $1' = 27''{\cdot}4$

$-26\ 46) = 43901{\cdot}6$ " " $43{\cdot}5$

$155696{\cdot}3$

$324000$

$m = 168303{\cdot}7$

$= 2032''{\cdot}1$, and as the change in $m$ for a change about $71''$, this requires an addition to $u$ of about een $28'$ and $29'$.

$u = 101^\circ\ 20'$, and repeating the process, if it is ery accurate, taking $\phi = 74^\circ\ 5'\ 53''{\cdot}8$ instead of ırn out that the correct value is $101^\circ\ 20'\ 33''{\cdot}2$, less than a tenth of second.

ıess can be often made more correct by taking (B) and finding an angle $\phi'$ such that

n $\phi' = e + e^2 \cos m$, whence (B) gives

$$u = \mathrm{C}\,(m - \phi') - \mathrm{C}\,(-m - \phi')$$

ximation. Or if $e + e^2 \cos m$ is greater than unity, $\phi'$

$$u = \mathrm{C}\,(m - 90^\circ) - \mathrm{C}\,(-m - 90^\circ).$$

known, $\varpi$ can be found from the column of differ-

$c$ being the length of the chord joining the two points and $k$ the measure of the attractive force at unit distance.

Equation (1) can be written

$$\frac{kt}{a^{\frac{3}{2}}} = \left\{\frac{\pi}{2} - \delta + \cos\left(\frac{\pi}{2} - \delta\right)\right\} - \left\{\frac{\pi}{2} - \varepsilon + \cos\left(\frac{\pi}{2} - \varepsilon\right)\right\}$$

or
$$\frac{\frac{1}{2}kt}{a^{\frac{3}{2}}} = C(90-\delta) - C(90-\varepsilon) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

if $k$ be expressed in seconds and $\delta$ and $\varepsilon$ in degrees and parts of a degree.

The angle $\delta$ lies between 0° and 180°, or between 180° and 360°, according as $\theta \sim \theta'$ is less or greater than 180°, while $\varepsilon$ is only restricted to lie between 0° and 360° (Gauss, *Theoria Motus*, ed. 2, Gotha, 1877, p. 132).

The three equations (1), (2), (3) are sufficient to determine $\delta$, $\varepsilon$, and $a$. The last two can be written

$$\sin^2\tfrac{1}{2}\delta = \frac{r+r'-c}{4a} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

$$\sin^2\tfrac{1}{2}\varepsilon = \frac{r+r'+c}{4a} \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

whence
$$\sin\tfrac{1}{2}\delta = \sqrt{\frac{r+r'-c}{r+r'+c}} \cdot \sin\tfrac{1}{2}\varepsilon \quad \ldots \quad \ldots \quad (7)$$

The following process of successive approximation will give the value of $a$ to as great a degree of accuracy as the data allow.

Assume any value for $\varepsilon$. From (7) the corresponding value of $\delta$ can be deduced, or, as is more useful in practice, $a$ can be first derived from (6) and then $\delta$ from (5).

Placing the values of $\delta$ and $\varepsilon$ in (4), by means of the tables of $C(\theta)$ another value of $a$ is obtained. Let the values of $a$ given by (6) and (4) be called $x$ and $y$ respectively.

Repeat this process with another assumed value of $\varepsilon$, and let $x'$ and $y'$ be the corresponding quantities on the second assumption. A comparison of $x' \sim y'$ with $x \sim y$ will indicate which of the two assumed values of $\varepsilon$ is nearer the truth, and, with practice, will also give to a considerable degree of correctness the distance of the required value from the original assumption.

Taking an example worked out by Gauss (*Theoria Motus*, p. 103), we have

$$\log r = 0{\cdot}3307640$$
$$\log r' = 0{\cdot}3222239$$
$$\theta' - \theta = 7^\circ\ 34'\ 53''{\cdot}73$$
$$t = 21{\cdot}93391 \text{ days}$$

Also
$$\log k = 3{\cdot}5500065746$$
$$\log t = 1{\cdot}3411160571$$

whence
$$\log(\tfrac{1}{2}kt) = 4{\cdot}5900926360$$

gonometrical processes give

$$c = 0{\cdot}2835079$$
$$r+r' = 4{\cdot}2417487$$
$$r+r'+c = 4{\cdot}5252566$$
$$r+r'-c = 3{\cdot}9582408$$
$$\log\frac{r+r'+c}{4} = 0{\cdot}0535832$$
$$\log\frac{r+r'-c}{4} = 9{\cdot}9954422$$

uess it is convenient to take $90°-\epsilon = 0$.

$$\mathrm{L}\sin\tfrac{1}{2}\epsilon = 9{\cdot}8494850$$
$$\log\sin^2\tfrac{1}{2}\epsilon = 9{\cdot}6989700$$
$$\log\frac{r+r'+c}{4} = 0{\cdot}0535832$$
$$\log x = 0{\cdot}3546132$$
$$\log\frac{r+r'-c}{4} = 9{\cdot}9954422$$
$$\log\sin^2\tfrac{1}{2}\delta = 9{\cdot}6408290$$
$$\mathrm{L}\sin\tfrac{1}{2}\delta = 9{\cdot}8204145$$

$= 41°\ 24'\ 3''{\cdot}4$ and $\delta = 82°\ 48'\ 6''{\cdot}8$

$$(90-\delta) = 7°\ 11'\ 53''{\cdot}2$$

the rate of change of $y$ being the greater. As here $y$ is less than $x$, it follows that in order to produce the required equality between them both must be increased, and $\epsilon$ and $\delta$ consequently diminished.

As a second guess take $\epsilon = 80°$. By the same process as above $\delta = 73° 54' 26''{\cdot}73$.

$$\log x = 0{\cdot}4374482$$
$$\log y = 0{\cdot}4407142$$

Thus $y$ is now greater than $x$, and the second value of $\epsilon$ is too small.

Roughly, the values of $x$ and $y$ for $\epsilon = 90°$ and $\epsilon = 80°$ are $x_1 = 2{\cdot}2626$, $y_1 = 2{\cdot}1735$, $x_2 = 2{\cdot}7381$, $y_2 = 2{\cdot}7588$. Thus

$$x_1 - y_1 = {\cdot}0891,\ y_2 - x_2 = {\cdot}0207$$

and, assuming that $x \sim y$ changes uniformly with $\epsilon$, this would give as the correct value of $\epsilon$ about $81° 53' 7''$.

In the later stages of approximation it is generally best to take two trial values of $\epsilon$ between which the real value lies, the simultaneous working of which is not much more labour than that of one separately, as far as reference to tables is concerned. A little practice will show what can easily be proved, that the rate of change of $y \sim x$ increases as $\delta$ decreases, and *vice versa*. Hence the real value of $\epsilon$ in this case is less than $81° 53' 7''$. Taking as two trial values for $\epsilon$, $81° 54'$ and $81° 30'$, the corresponding values of $\delta$ are $75° 36' 30''{\cdot}6$ and $75° 15' 2''{\cdot}74$, while the values of $\log x$ and $\log y$ are given by

$$\left.\begin{aligned}\log x_1 &= 0{\cdot}4205700\\ \log y_1 &= 0{\cdot}4201511\end{aligned}\right\} \text{ and } \begin{aligned}\log x_2 &= 0{\cdot}4240764\\ \log y_2 &= 0{\cdot}4244420\end{aligned}$$

The required value of $\epsilon$ must evidently therefore lie between $81° 30'$ and $81° 54'$, and not very far from halfway between them. As another pair of trial values taking $\epsilon = 81° 40'$ and $\epsilon = 81° 42'$, by the same process it will be found that

$$\left.\begin{aligned}\log x_1 &= 0{\cdot}4226124\\ \log y_1 &= 0{\cdot}4226428\end{aligned}\right\} \quad \begin{aligned}\log x_2 &= 0{\cdot}4223202\\ \log y_2 &= 0{\cdot}4222933\end{aligned}$$

The real value of $\epsilon$ is thus intermediate between these two.

The value of $a$ must therefore lie between $x_1$ and $x_2$: that is, between 2·6461 and 2·6443. In many cases this will be near enough, but if greater accuracy is required a pair of closer values may be tried, from which it will be found that for $\epsilon = 81° 41' 11''{\cdot}5$, the values of $\log x$ and $\log y$ coincide for seven figures, each of them being 0·4224385. The value given by Gauss is 0·4224389, the discrepancy being within the limits of error accumulating in the use of seven-figure logarithms.

The discovery of the value of $a$, by means of the equations

), may be considered as the discovery of the point of two curves whose equations are of the forms

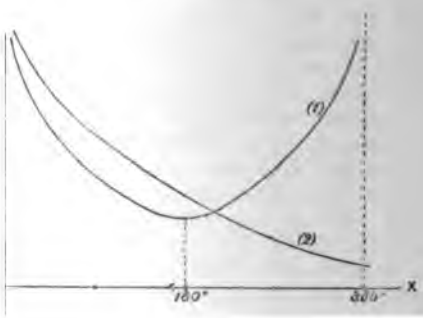
$$y = \frac{\lambda}{\sin^2 \frac{1}{2}x} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$\frac{\mu}{y^{\frac{3}{2}}} = (x' - \sin x') - (x - \sin x) \quad \ldots \quad \ldots \quad (2)$$

unction of $x$ given by an equation of the form

$$\sin \tfrac{1}{2}x' = \nu \sin \tfrac{1}{2}x,$$

iven constants.
te of the point of intersection is the required value



The formulæ for this purpose are easily shown to be

$$p = \frac{2rr'\sin^2\Delta}{c}\tan\tfrac{1}{2}\psi \text{ or } \frac{2rr'\sin^2\Delta}{c}\cot\tfrac{1}{2}\psi$$

where $p$ is the semilatus rectum, $2\Delta$ the angle between the given radii vectores, and $\psi$ an acute angle determined by the equation

$$\left(r+r'-\frac{rr'\cos^2\Delta}{a}\right)\sin\psi = c.$$

In the formula for $p$ the value $\tan\frac{1}{2}\psi$ or $\cot\frac{1}{2}\psi$ has to be taken according as $2\Delta$, or $\theta'-\theta$ is greater or less than 180°. When $p$ is known and $a$, the value of $e$ can be obtained from the formula $p = a(1-e^2)$, or if $e = \sin\phi$, $\cos\phi = \sqrt{\frac{p}{a}}$.

In using this method for finding $a$ it is better to make an assumption for the value of $\epsilon$ than for that of $\delta$ although the range of possible values for the former is double that for the latter, for two reasons. First, for any assumed value of $\epsilon$, equation (7) only gives one value of $\delta$, while for an assumed value of $\delta$ it would give two possible ones for $\epsilon$; secondly, any assumed value for $\epsilon$ will give a real value for $\delta$, while this would not always be the case if the opposite method were adopted.

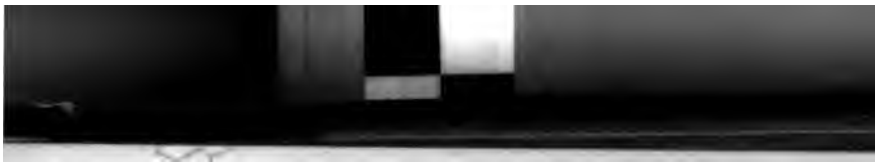
In the tables negative values of $C(\theta)$ are denoted by a black line at the right of the column.

In cases where there was a little doubt as to whether the figure after the fourth decimal ought to be 5+ or 5−, so that there was uncertainty as to the exact value of the last figure retained, that value has been chosen which made the sequence of the second differences most regular.

A dot placed after a decimal whose last significant figure is 5, thus ·6345. or ·6350. denotes that the real value is slightly less. This enables the last digit or two digits to be cut off with accuracy in all cases.

The writer desires to acknowledge his obligation to Professor G. H. Darwin for valuable hints as to the construction and the method of application of the Tables.

| | | $-\sigma^3$. | Diff. | $\Delta^4$. | $\Delta^3$. | Diff. | $\iota^2$. |
|---|---|---|---|---|---|---|---|
| | | " | " | | | ' | " |
| 931 | 0 | 103132·4031 | | 86 | 87 | | 104916·695 |
| 888 | 1 | 102·3988 | 30·0043 | 88 | 88 | 29·4721 | 946·167 |
| 857 | 2 | 072·3857 | ·0131 | 87 | 87 | ·4633 | 104975·631 |
| 839 | 3 | 042·3639 | ·0218 | 88 | 87 | ·4546 | 105005·085 |
| 833 | 4 | 103012·3333 | ·0306 | 87 | 88 | ·4459 | 034·531 |
| 840 | 5 | 102982·2940 | ·0393 | 87 | 86 | ·4371 | 063·968 |
| 860 | 6 | 952·2460 | ·0480 | 87 | 88 | ·4285 | 093·397 |
| 893 | 7 | 922·1893 | ·0567 | 87 | 87 | ·4197 | 122·816 |
| 939 | 8 | 892·1239 | ·0654 | 88 | 88 | ·4110 | 152·227 |
| 997 | 9 | 862·0497 | ·0742 | 87 | 86 | ·4022 | 181·630 |
| | | | ·0829 | | | ·3936 | |
| 968 | 10 | 831·9668 | ·0916 | 87 | 88 | ·3848 | 211·023 |
| 752 | 1 | 801·8752 | ·1004 | 88 | 87 | ·3761 | 240·408 |
| 748 | 2 | 771·7748 | ·1091 | 87 | 88 | ·3673 | 269·784 |
| 757 | 3 | 741·6657 | ·1178 | 87 | 86 | ·3587 | 299·151 |
| 779 | 4 | 711·5479 | ·1265 | 87 | 88 | ·3499 | 328·510 |
| 814 | 15 | 681·4214 | ·1353 | 88 | 87 | ·3412 | 357·860 |
| 861 | 6 | 651·2861 | ·1440 | 87 | 88 | ·3324 | 387·201 |
| 921 | 7 | 621·1421 | ·1527 | 87 | 86 | ·3238 | 416·534 |
| 994 | 8 | 590·9894 | ·1614 | 87 | 88 | ·3150 | 445·857 |
| 080 | 9 | 560·8280 | ·1702 | 88 | 87 | ·3063 | 475·172 |
| 178 | 20 | 530·6578 | ·1789 | 87 | 87 | ·2976 | 504·479 |
| 289 | 1 | 500·4789 | ·1876 | 87 | 88 | ·2888 | 533·776 |
| 413 | 2 | 470·2913 | ·1963 | 87 | 87 | ·2801 | 563·065 |
| 550 | 3 | 440·0950. | ·2051 | 88 | 87 | ·2714 | 592·345 |
| 699 | 4 | 409·8899 | ·2138 | 87 | 87 | ·2627 | 621·617 |
| 861 | 25 | 379·6761 | ·2225 | 87 | 87 | ·2540 | 650·879 |
| 536 | 6 | 349·4536 | ·2313 | 88 | 88 | ·2452 | 680·133 |
| 223 | 7 | 319·2223 | ·2400 | 87 | 87 | ·2365 | 709·378 |
| 823 | 8 | 288·9823 | ·2487 | 87 | 88 | ·2277 | 738·615 |
| 436 | 9 | 258·7336 | ·2574 | 87 | 86 | ·2191 | 767·843 |
| 762 | 30 | 228·4762 | ·2662 | 88 | 88 | ·2103 | 797·062 |
| 100 | 1 | 198·2100 | ·2749 | 87 | 87 | ·2016 | 826·272 |
| 351 | 2 | 167·9351 | ·2836 | 87 | 87 | ·1929 | 855·474 |
| 615 | 3 | 137·6515. | | 88 | 87 | | 884·667 |





| ′ | −1°. | Diff. | Δ². | Δ². | Diff. | 2°. | ′ | −2°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|---|
| | ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 0 | 101316·6956 | 30·5279 | 87 | 86 | 28·9487 | 106669·5776 | 0 | 99469·5776 | 31·0513 | 86 |
| 1 | 286·1677 | ·5367 | 88 | 88 | ·9399 | 698·5263 | 1 | 438·5263 | ·0601 | 88 |
| 2 | 255·6310 | ·5454 | 87 | 87 | ·9312 | 727·4662 | 2 | 407·4662 | ·0688 | 87 |
| 3 | 225·0856 | ·5541 | 87 | 87 | ·9225 | 756·3974 | 3 | 376·3974 | ·0775 | 87 |
| 4 | 194·5315. | ·5629 | 88 | 87 | ·9138 | 785·3199 | 4 | 345·3199 | ·0862 | 87 |
| 5 | 163·9686 | ·5715 | 86 | 88 | ·9050 | 814·2337 | 5 | 314·2337 | ·0950 | 88 |
| 6 | 133·3971 | ·5803 | 88 | 86 | ·8964 | 843·1387 | 6 | 283·1387 | ·1036 | 86 |
| 7 | 102·8168 | ·5890 | 87 | 88 | ·8876 | 872·0351 | 7 | 252·0351 | ·1124 | 88 |
| 8 | 072·2278 | ·5978 | 88 | 87 | ·8789 | 900·9227 | 8 | 220·9227 | ·1211 | 87 |
| 9 | 041·6300 | ·6064 | 86 | 88 | ·8701 | 929·8016 | 9 | 189·8016 | ·1299 | 88 |
| 10 | 101011·0236 | ·6152 | 88 | 86 | ·8615 | 958·6717 | 10 | 158·6717 | ·1385 | 86 |
| 1 | 100980·4084 | ·6239 | 87 | 88 | ·8527 | 106987·5332 | 1 | 127·5332 | ·1473 | 88 |
| 2 | 949·7845. | ·6327 | 88 | 87 | ·8440 | 107016·3859 | 2 | 096·3859 | ·1560 | 87 |
| 3 | 919·1518 | ·6413 | 86 | 87 | ·8353 | 045·2299 | 3 | 065·2299 | ·1647 | 87 |
| 4 | 888·5105. | ·6501 | 88 | 87 | ·8266 | 074·0652 | 4 | 034·0652 | ·1734 | 87 |
| 15 | 857·8604 | ·6588 | 87 | 88 | ·8178 | 102·8918 | 15 | 99002·8918 | ·1822 | 88 |
| 6 | 827·2016 | ·6676 | 88 | 87 | ·8091 | 131·7096 | 6 | 98971·7096 | ·1909 | 87 |
| 7 | 796·5340 | ·6762 | 86 | 87 | ·8004 | 160·5187 | 7 | 940·5187 | ·1996 | 87 |
| 8 | 765·8578 | ·6850 | 88 | 87 | ·7917 | 189·3191 | 8 | 909·3191 | ·2083 | 87 |
| 9 | 735·1728 | ·6937 | 87 | 87 | ·7830 | 218·1108 | 9 | 878·1108 | ·2170 | 87 |
| 20 | 704·4791 | ·7024 | 87 | 88 | ·7742 | 246·8938 | 20 | 846·8938 | ·2258 | 88 |
| 1 | 673·7767 | ·7112 | 88 | 86 | ·7656 | 275·6680 | 1 | 815·6680 | ·2344 | 86 |
| 2 | 643·0655 | ·7199 | 87 | 88 | ·7568 | 304·4336 | 2 | 784·4336 | ·2432 | 88 |
| 3 | 612·3456 | ·7286 | 87 | 87 | ·7481 | 333·1904 | 3 | 753·1904 | ·2519 | 87 |
| 4 | 581·6170 | ·7373 | 87 | 88 | ·7393 | 361·9385. | 4 | 721·9385. | ·2607 | 88 |
| 25 | 550·8797 | ·7460 | 87 | 86 | ·7307 | 390·6778 | 25 | 690·6778 | ·2693 | 86 |
| 6 | 520·1337 | ·7548 | 88 | 88 | ·7219 | 419·4085. | 6 | 659·4085. | ·2781 | 88 |
| 7 | 489·3789 | ·7635 | 87 | 87 | ·7132 | 448·1304 | 7 | 628·1304 | ·2868 | 87 |
| 8 | 458·6154 | ·7723 | 88 | 87 | ·7045 | 476·8436 | 8 | 596·8436 | ·2955 | 87 |
| 9 | 427·8431 | ·7809 | 86 | 87 | ·6958 | 505·5481 | 9 | 565·5481 | ·3042 | 87 |
| 30 | 397·0622 | ·7897 | 88 | 87 | ·6871 | 534·2439 | 30 | 534·2439 | ·3129 | 87 |
| 1 | 366·2725 | ·7984 | 87 | 88 | ·6783 | 562·9310 | 1 | 502·9310 | ·3217 | 88 |
| 2 | 335·4741 | ·8071 | 87 | 87 | ·6696 | 591·6093 | 2 | 471·6093 | ·3304 | 87 |
| 3 | 304·6670 | ·8158 | 87 | 87 | ·6609 | 620·2789 | 3 | 440·2789 | ·3391 | 87 |
| 4 | 273·8512 | ·8246 | 88 | 87 | ·6522 | 648·9398 | 4 | 408·9398 | ·3478 | 87 |
| 35 | 243·0266 | ·8333 | 87 | 87 | ·6435 | 677·5920 | 35 | 377·5920 | ·3565 | 87 |
| 6 | 212·1933 | ·8420 | 87 | 87 | ·6348 | 706·2355. | 6 | 346·2355. | ·3652 | 87 |
| 7 | 181·3513 | ·8507 | 87 | 88 | ·6260 | 734·8703 | 7 | 314·8703 | ·3740 | 88 |
| 8 | 150·5006 | ·8595 | 88 | 87 | ·6173 | 763·4963 | 8 | 283·4963 | ·3827 | 87 |
| 9 | 119·6411 | ·8681 | 86 | 87 | ·6086 | 792·1136 | 9 | 252·1136 | ·3914 | 87 |
| 40 | 088·7730 | ·8769 | 88 | 87 | ·5999 | 820·7222 | 40 | 220·7222 | ·4001 | 87 |
| 1 | 057·8961 | ·8857 | 88 | 87 | ·5912 | 849·3221 | 1 | 189·3221 | ·4088 | 87 |
| 2 | 100027·0104 | ·8943 | 86 | 88 | ·5824 | 877·9133 | 2 | 157·9133 | ·4176 | 88 |
| 3 | 99996·1161 | ·9031 | 88 | 87 | ·5737 | 906·4957 | 3 | 126·4957 | ·4263 | 87 |
| 4 | 965·2130 | ·9118 | 87 | 87 | ·5650 | 935·0694 | 4 | 095·0694 | ·4350 | 87 |
| 45 | 934·3012 | ·9205 | 87 | 87 | ·5563 | 963·6344 | 45 | 063·6344 | ·4437 | 87 |
| 6 | 903·3807 | ·9292 | 87 | 87 | ·5476 | 107992·1907 | 6 | 032·1907 | ·4524 | 87 |
| 7 | 872·4515. | ·9380 | 88 | 87 | ·5389 | 108020·7383 | 7 | 98000·7383 | ·4611 | 87 |
| 8 | 841·5135. | ·9467 | 87 | 88 | ·5301 | 049·2772 | 8 | 97969·2772 | ·4699 | 88 |
| 9 | 810·5668 | ·9554 | 87 | 87 | ·5214 | 077·8073 | 9 | 937·8073 | ·4786 | 87 |
| 50 | 779·6114 | ·9641 | 87 | 86 | ·5128 | 106·3287 | 50 | 906·3287 | ·4872 | 86 |
| 1 | 748·6473 | ·9729 | 88 | 88 | ·5040 | 134·8415. | 1 | 874·8415. | ·4960 | 88 |
| 2 | 717·6744 | ·9816 | 87 | 87 | ·4953 | 163·3455 | 2 | 843·3455 | ·5047 | 87 |
| 3 | 686·6928 | ·9903 | 87 | 88 | ·4865 | 191·8408 | 3 | 811·8408 | ·5135 | 88 |
| 4 | 655·7025 | 30·9990 | 87 | 86 | ·4779 | 220·3273 | 4 | 780·3273 | ·5221 | 86 |
| 55 | 624·7035 | 31·0077 | 87 | 88 | ·4691 | 248·8052 | 55 | 748·8052 | ·5309 | 88 |
| 6 | 593·6958 | ·0164 | 87 | 87 | ·4604 | 277·2743 | 6 | 717·2743 | ·5396 | 87 |
| 7 | 562·6794 | ·0252 | 88 | 87 | ·4517 | 305·7347 | 7 | 685·7347 | ·5483 | 87 |
| 8 | 531·6542 | ·0339 | 87 | 86 | ·4431 | 334·1864 | 8 | 654·1864 | ·5569 | 86 |
| 9 | 500·6203 | 31·0427 | 88 | 88 | ·4343 | 362·6295. | 9 | 622·6295. | 31·5657 | 88 |
| 60 | 99469·5776 | | | | 28 | 108391·0638 | 60 | 97591·0638 | | |

| ′. | ′ | −3°. | Diff. | Δ². | Δ². | Diff. | 4°. |
|---|---|---|---|---|---|---|---|
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| 0638 | 0 | 97591·0638 | 31·5745 | 88 | 86 | 27·9030 | 110081·177 |
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| 9061 | 2 | 527·9061 | ·5918 | 86 | 88 | ·8855 | 135·975 |
| 3143 | 3 | 496·3143 | ·6006 | 88 | 87 | ·8768 | 164·860 |
| 7137 | 4 | 464·7137 | ·6093 | 87 | 86 | ·8682 | 192·737 |
| 1044 | 5 | 433·1044 | ·6180 | 87 | 88 | ·8594 | 220·605 |
| 4864 | 6 | 401·4864 | ·6267 | 87 | 86 | ·8508 | 248·464 |
| 8597 | 7 | 369·8597 | ·6355 | 88 | 88 | ·8420 | 276·315 |
| 2242 | 8 | 338·2242 | ·6441 | 86 | 87 | ·8333 | 304·157 |
| 5801 | 9 | 306·5801 | ·6529 | 88 | 87 | ·8246 | 331·991 |
| 9272 | 10 | 274·9272 | ·6615 | 86 | 87 | ·8159 | 359·815 |
| 2657 | 1 | 243·2657 | ·6703 | 88 | 87 | ·8072 | 387·631 |
| 5954 | 2 | 211·5954 | ·6790 | 87 | 87 | ·7985 | 415·438 |
| 9164 | 3 | 179·9164 | ·6878 | 88 | 87 | ·7898 | 443·237 |
| 2286 | 4 | 148·2286 | ·6964 | 86 | 87 | ·7811 | 471·027 |
| 5322 | 15 | 116·5322 | ·7051 | 87 | 87 | ·7724 | 498·808 |
| 8271 | 6 | 084·8271 | ·7139 | 88 | 87 | ·7637 | 526·580 |
| 1132 | 7 | 053·1132 | ·7225 | 86 | 87 | ·7550 | 554·344 |
| 3907 | 8 | 97021·3907 | ·7313 | 88 | 88 | ·7462 | 582·099 |
| 6594 | 9 | 96989·6594 | ·7400 | 87 | 86 | ·7376 | 609·845 |
| 9194 | 20 | 957·9194 | ·7487 | 87 | 87 | ·7289 | 637·583 |
| 1707 | 1 | 926·1707 | ·7574 | 87 | 87 | ·7202 | 665·312 |
| 4133 | 2 | 894·4133 | ·7661 | 87 | 87 | ·7115 | 693·032 |
| 6472 | 3 | 862·6472 | ·7749 | 88 | 88 | ·7027 | 720·743 |
| 8723 | 4 | 830·8723 | ·7835 | 86 | 86 | ·6941 | 748·445 |
| 0888 | 25 | 799·0888 | ·7923 | 88 | 87 | ·6854 | 776·139 |
| 2965 | 6 | 767·2965 | ·8009 | 86 | 87 | ·6767 | 803·824 |
| 4956 | 7 | 735·4956 | ·8097 | 88 | 87 | ·6680 | 831·502 |
| 6859 | 8 | 703·6859 | ·8184 | 87 | 87 | ·6593 | 859·170 |
| 8675. | 9 | 671·8675. | ·8271 | 87 | 87 | ·6506 | 886·829 |
| 0404 | 30 | 640·0404 | ·8358 | 87 | 88 | ·6418 | 914·480 |
| 2046 | 1 | 608·2046 | ·8445 | 87 | 86 | ·6332 | 942·122 |
| 3601 | 2 | 576·3601 | ·8533 | 88 | 87 | ·6245 | 969·755 |
| 5068 | 3 | 544·5068 | | 86 | 88 | | 110097·378 |

| ′ | −4°. | Diff. | Δ². | Δ². | Diff. | 5°. | ′ | −5°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|---|
| | ′ | ″ | | | ″ | ″ | | ″ | ″ | |
| 0 | 95681·1777 | | 86 | 88 | | 111739·9532 | 0 | 93739·9532 | | 88 |
| | | 32·0970 | | | 27·3809 | | | | 32·6191 | |
| 1 | 649·0807 | | 87 | 86 | | 767·3341 | 1 | 707·3341 | | 86 |
| | | ·1057 | | | ·3723 | | | | ·6277 | |
| 2 | 616·9750. | | 88 | 86 | | 794·7064 | 2 | 674·7064 | | 86 |
| | | ·1145 | | | ·3637 | | | | ·6363 | |
| 3 | 584·8605 | | 87 | 88 | | 822·0701 | 3 | 642·0701 | | 88 |
| | | ·1232 | | | ·3549 | | | | ·6451 | |
| 4 | 552·7373 | | 86 | 87 | | 849·4250. | 4 | 609·4250. | | 87 |
| | | ·1318 | | | ·3462 | | | | ·6538 | |
| 5 | 520·6055. | | 88 | 87 | | 876·7712 | 5 | 576·7712 | | 87 |
| | | ·1406 | | | ·3375 | | | | ·6625 | |
| 6 | 488·4649 | | 86 | 87 | | 904·1087 | 6 | 544·1087 | | 87 |
| | | ·1492 | | | ·3288 | | | | ·6712 | |
| 7 | 456·3157 | | 88 | 87 | | 931·4375 | 7 | 511·4375 | | 87 |
| | | ·1580 | | | ·3201 | | | | ·6799 | |
| 8 | 424·1577 | | 87 | 86 | | 958·7576 | 8 | 478·7576 | | 86 |
| | | ·1667 | | | ·3115 | | | | ·6885 | |
| 9 | 391·9910 | | 87 | 88 | | 111986·0691 | 9 | 446·0691 | | 88 |
| | | ·1754 | | | ·3027 | | | | ·6973 | |
| 10 | 359·8156 | | 87 | 86 | | 112013·3718 | 10 | 413·3718 | | 86 |
| | | ·1841 | | | ·2941 | | | | ·7059 | |
| 1 | 327·6315. | | 87 | 87 | | 040·6659 | 1 | 380·6659 | | 87 |
| | | ·1928 | | | ·2854 | | | | ·7146 | |
| 2 | 295·4387 | | 87 | 88 | | 067·9513 | 2 | 347·9513 | | 88 |
| | | ·2015 | | | ·2766 | | | | ·7234 | |
| 3 | 263·2372 | | 87 | 86 | | 095·2279 | 3 | 315·2279 | | 86 |
| | | ·2102 | | | ·2680 | | | | ·7320 | |
| 4 | 231·0270 | | 87 | 87 | | 122·4959 | 4 | 282·4959 | | 87 |
| | | ·2189 | | | ·2593 | | | | ·7407 | |
| 15 | 198·8081 | | 87 | 87 | | 149·7552 | 15 | 249·7552 | | 87 |
| | | ·2276 | | | ·2506 | | | | ·7494 | |
| 6 | 166·5805 | | 87 | 87 | | 177·0058 | 6 | 217·0058 | | 87 |
| | | ·2363 | | | ·2419 | | | | ·7581 | |
| 7 | 134·3442 | | 87 | 86 | | 204·2477 | 7 | 184·2477 | | 86 |
| | | ·2450 | | | ·2333 | | | | ·7667 | |
| 8 | 102·0992 | | 88 | 88 | | 231·4810 | 8 | 151·4810 | | 88 |
| | | ·2538 | | | ·2245 | | | | ·7755 | |
| 9 | 069·8454 | | 86 | 86 | | 258·7055 | 9 | 118·7055 | | 86 |
| | | ·2624 | | | ·2159 | | | | ·7841 | |
| 20 | 037·5830 | | 87 | 88 | | 285·9214 | 20 | 085·9214 | | 88 |
| | | ·2711 | | | ·2071 | | | | ·7929 | |
| 1 | 95005·3119 | | 87 | 86 | | 313·1285. | 1 | 053·1285. | | 86 |
| | | ·2798 | | | ·1985 | | | | ·8015 | |
| 2 | 94973·0321 | | 87 | 87 | | 340·3270 | 2 | 93020·3270 | | 87 |
| | | ·2885 | | | ·1898 | | | | ·8102 | |
| 3 | 940·7436 | | 88 | 87 | | 367·5168 | 3 | 92987·5168 | | 87 |
| | | ·2973 | | | ·1811 | | | | ·8189 | |
| 4 | 908·4463 | | 86 | 87 | | 394·6979 | 4 | 954·6979 | | 87 |
| | | ·3059 | | | ·1724 | | | | ·8276 | |
| 25 | 876·1404 | | 87 | 87 | | 421·8703 | 25 | 921·8703 | | 87 |
| | | ·3146 | | | ·1637 | | | | ·8363 | |
| 6 | 843·8258 | | 87 | 87 | | 449·0340 | 6 | 889·0340 | | 87 |
| | | ·3233 | | | ·1550 | | | | ·8450 | |
| 7 | 811·5025 | | 87 | 86 | | 476·1890 | 7 | 856·1890 | | 86 |
| | | ·3320 | | | ·1464 | | | | ·8536 | |
| 8 | 779·1705. | | 87 | 88 | | 503·3354 | 8 | 823·3354 | | 88 |
| | | ·3407 | | | ·1376 | | | | ·8624 | |
| 9 | 746·8298 | | 87 | 86 | | 530·4730 | 9 | 790·4730 | | 86 |
| | | ·3494 | | | ·1290 | | | | ·8710 | |
| 30 | 714·4804 | | 88 | 87 | | 557·6020 | 30 | 757·6020 | | 87 |
| | | ·3582 | | | ·1203 | | | | ·8797 | |
| 1 | 682·1222 | | 86 | 87 | | 584·7223 | 1 | 724·7223 | | 87 |
| | | ·3668 | | | ·1116 | | | | ·8884 | |
| 2 | 649·7554 | | 87 | 87 | | 611·8339 | 2 | 691·8339 | | 87 |
| | | ·3755 | | | ·1029 | | | | ·8971 | |
| 3 | 617·3799 | | 88 | 87 | | 638·9368 | 3 | 658·9368 | | 87 |
| | | ·3843 | | | ·0942 | | | | ·9058 | |
| 4 | 584·9956 | | 86 | 87 | | 666·0310 | 4 | 626·0310 | | 87 |
| | | ·3929 | | | ·0855 | | | | ·9145 | |
| 35 | 552·6027 | | 87 | 86 | | 693·1165 | 35 | 593·1165 | | 86 |
| | | ·4016 | | | ·0769 | | | | ·9231 | |
| 6 | 520·2011 | | 87 | 87 | | 720·1934 | 6 | 560·1934 | | 87 |
| | | ·4103 | | | ·0682 | | | | ·9318 | |
| 7 | 487·7908 | | 87 | 87 | | 747·2616 | 7 | 527·2616 | | 87 |
| | | ·4190 | | | ·0595 | | | | ·9405 | |
| 8 | 455·3718 | | 88 | 87 | | 774·3211 | 8 | 494·3211 | | 87 |
| | | ·4278 | | | ·0508 | | | | ·9492 | |
| 9 | 422·9440 | | 86 | 87 | | 801·3719 | 9 | 461·3719 | | 87 |
| | | ·4364 | | | ·0421 | | | | ·9579 | |
| 40 | 390·5076 | | 87 | 87 | | 828·4140 | 40 | 428·4140 | | 87 |
| | | ·4451 | | | ·0334 | | | | ·9666 | |
| 1 | 358·0625 | | 87 | 86 | | 855·4474. | 1 | 395·4474. | | 86 |
| | | ·4538 | | | ·0248 | | | | ·9752 | |
| 2 | 325·6087 | | 87 | 88 | | 882·4722 | 2 | 362·4722 | | 88 |
| | | ·4625 | | | ·0160 | | | | ·9840 | |
| 3 | 293·1462 | | 87 | 86 | | 909·4882 | 3 | 329·4882 | | 86 |
| | | ·4712 | | | 27·0074 | | | | 32·9926 | |
| 4 | 260·6750 | | 87 | 87 | | 936·4956 | 4 | 296·4956 | | 87 |
| | | ·4799 | | | 26·9987 | | | | 33·0013 | |
| 45 | 228·1951 | | 87 | 87 | | 963·4943 | 45 | 263·4943 | | 87 |
| | | ·4886 | | | ·9900 | | | | ·0100 | |
| 6 | 195·7065. | | 87 | 86 | | 112990·4843 | 6 | 230·4843 | | 86 |
| | | ·4973 | | | ·9814 | | | | ·0186 | |
| 7 | 163·2092 | | 86 | 88 | | 113017·4657 | 7 | 197·4657 | | 88 |
| | | ·5059 | | | ·9726 | | | | ·0274 | |
| 8 | 130·7033 | | 88 | 86 | | 044·4383 | 8 | 164·4383 | | 86 |
| | | ·5147 | | | ·9640 | | | | ·0360 | |
| 9 | 098·1886 | | 87 | 87 | | 071·4023 | 9 | 131·4023 | | 87 |
| | | ·5234 | | | ·9553 | | | | ·0447 | |
| 50 | 065·6652 | | 87 | 87 | | 098·3576 | 50 | 098·3576 | | 87 |
| | | ·5321 | | | ·9466 | | | | ·0534 | |
| 1 | 033·1331 | | 87 | 87 | | 125·3042 | 1 | 065·3042 | | 87 |
| | | ·5408 | | | ·9379 | | | | ·0621 | |
| 2 | 94000·5923 | | 86 | 86 | | 152·2421 | 2 | 92032·2421 | | 86 |
| | | ·5494 | | | ·9293 | | | | ·0707 | |
| 3 | 93968·0429 | | 88 | 88 | | 179·1714 | 3 | 91999·1714 | | 88 |
| | | ·5582 | | | ·9205 | | | | ·0795 | |
| 4 | 935·4847 | | 86 | 86 | | 206·0919 | 4 | 966·0919 | | 86 |
| | | ·5668 | | | ·9119 | | | | ·0881 | |
| 55 | 902·9179 | | 88 | 87 | | 233·0038 | 55 | 933·0038 | | 87 |
| | | ·5756 | | | ·9032 | | | | ·0968 | |
| 6 | 870·3423 | | 86 | 87 | | 259·9070 | 6 | 899·9070 | | 87 |
| | | ·5842 | | | ·8945 | | | | ·1055 | |
| 7 | 837·7581 | | 88 | 86 | | 286·8015 | 7 | 866·8015 | | 86 |
| | | ·5930 | | | ·8859 | | | | ·1141 | |
| 8 | 805·1651 | | 86 | 88 | | 313·6874 | 8 | 833·6874 | | 88 |
| | | ·6016 | | | ·8771 | | | | ·1229 | |
| 9 | 772·5635 | | 87 | 86 | | 340·5645 | 9 | 800·5645 | | 86 |
| | | 32·6103 | | | 26·8685 | | | | 33·1315 | |
| 60 | 93739·9532 | | | | | 113367·4330 | 60 | 91767·4330 | | |

| | ′ | $-6^2$. | Diff. | $\Delta^1$. | $\Delta^1$. | Diff. | $7^2$. |
|---|---|---|---|---|---|---|---|
| | | " | " | | | " | " |
| 30 | 0 | 91767·4330 | 33·1402 | 87 | 86 | 26·3396 | 114563·66 |
| 28 | 1 | 734·2928 | ·1488 | 86 | 86 | ·3310 | 114990·00 |
| 40 | 2 | 701·1440 | ·1576 | 88 | 88 | ·3222 | 115316·34 |
| 64 | 3 | 667·9864 | ·1662 | 86 | 86 | ·3136 | 052·66 |
| 02 | 4 | 634·8202 | ·1749 | 87 | 87 | ·3049 | 068·97 |
| 53 | 5 | 601·6453 | ·1836 | 87 | 86 | ·2963 | 095·23 |
| 17 | 6 | 568·4617 | ·1923 | 87 | 86 | ·2877 | 121·57 |
| 94 | 7 | 535·2694 | ·2009 | 86 | 88 | ·2789 | 147·86 |
| 85 | 8 | 502·0685 | ·2096 | 87 | 86 | ·2703 | 174·14 |
| 89 | 9 | 468·8589 | ·2183 | 87 | 86 | ·2617 | 200·41 |
| 06 | 10 | 435·6406 | ·2270 | 87 | 87 | ·2530 | 226·67 |
| 36 | 1 | 402·4136 | ·2356 | 86 | 87 | ·2443 | 252·92 |
| 80 | 2 | 369·1780 | ·2443 | 87 | 86 | ·2357 | 279·17 |
| 37 | 3 | 335·9337 | ·2530 | 87 | 87 | ·2270 | 305·40 |
| 07 | 4 | 302·6807 | ·2617 | 87 | 87 | ·2183 | 331·63 |
| 90 | 15 | 269·4190 | ·2703 | 86 | 86 | ·2097 | 357·85 |
| 87 | 6 | 236·1487 | ·2791 | 88 | 86 | ·2011 | 384·06 |
| 96 | 7 | 202·8696 | ·2877 | 86 | 87 | ·1924 | 410·26 |
| 19 | 8 | 169·5819 | ·2963 | 86 | 87 | ·1837 | 436·45 |
| 56 | 9 | 136·2856 | ·3051 | 88 | 86 | ·1751 | 462·64 |
| 05 | 20 | 102·9805 | ·3137 | 86 | 87 | ·1664 | 488·81 |
| 68 | 1 | 069·6668 | ·3224 | 87 | 86 | ·1578 | 514·98 |
| 44 | 2 | 036·3444 | ·3310 | 86 | 87 | ·1491 | 541·14 |
| 34 | 3 | 91003·0134 | ·3397 | 87 | 86 | ·1405 | 567·28 |
| 37 | 4 | 90969·6737 | ·3484 | 87 | 87 | ·1318 | 593·43 |
| 53 | 25 | 936·3253 | ·3571 | 87 | 87 | ·1231 | 619·56 |
| 82 | 6 | 902·9682 | ·3658 | 87 | 86 | ·1145 | 645·69 |
| 24 | 7 | 869·6024 | ·3744 | 86 | 86 | ·1059 | 671·79 |
| 80 | 8 | 836·2280 | ·3831 | 87 | 87 | ·0972 | 697·90 |
| 49 | 9 | 802·8449 | ·3918 | 87 | 87 | ·0885 | 724·00 |
| 31 | 30 | 769·4531 | ·4004 | 86 | 86 | ·0799 | 750·09 |
| 27 | 1 | 736·0527 | ·4091 | 87 | 87 | ·0712 | 776·17 |
| 36 | 2 | 702·6436 | ·4178 | 87 | 86 | ·0626 | 802·24 |
| 58 | 3 | 669·2258 | | 86 | 86 | | 828·30 |





| ′ | −7°. | Diff. | Δ². | Δ². | Diff. | 8°. | ′ | −8°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|---|
| | ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 0 | 89763·6698 | | 86 | 87 | | 116528·7257 | 0 | 87728·7257 | | 87 |
| | | 33·6604 | | | 25·8205 | | | | 34·1795 | |
| 1 | 730·0094 | ·6690 | 86 | 87 | ·8118 | 554·5462 | 1 | 694·5462 | ·1882 | 87 |
| 2 | 696·3404 | ·6778 | 88 | 86 | ·8032 | 580·3580 | 2 | 660·3580 | ·1968 | 86 |
| 3 | 662·6626 | ·6864 | 86 | 87 | ·7945 | 606·1612 | 3 | 626·1612 | ·2055 | 87 |
| 4 | 628·9762 | ·6951 | 87 | 85 | ·7860 | 631·9557 | 4 | 591·9557 | ·2140 | 85 |
| 5 | 595·2811 | ·7037 | 86 | 87 | ·7773 | 657·7417 | 5 | 557·7417 | ·2227 | 87 |
| 6 | 561·5774 | ·7123 | 86 | 87 | ·7686 | 683·5190 | 6 | 523·5190 | ·2314 | 87 |
| 7 | 527·8651 | ·7211 | 88 | 86 | ·7600 | 709·2876 | 7 | 489·2876 | ·2400 | 86 |
| 8 | 494·1440 | ·7297 | 86 | 86 | ·7514 | 735·0476 | 8 | 455·0476 | ·2486 | 86 |
| 9 | 460·4143 | ·7383 | 86 | 87 | ·7427 | 760·7990 | 9 | 420·7990 | ·2573 | 87 |
| 10 | 426·6760 | ·7470 | 87 | 86 | ·7341 | 786·5417 | 10 | 386·5417 | ·2659 | 86 |
| 1 | 392·9290 | ·7557 | 87 | 86 | ·7255 | 812·2758 | 1 | 352·2758 | ·2745 | 86 |
| 2 | 359·1733 | ·7643 | 86 | 88 | ·7167 | 838·0013 | 2 | 318·0013 | ·2833 | 88 |
| 3 | 325·4090 | ·7730 | 87 | 85 | ·7082 | 863·7180 | 3 | 283·7180 | ·2918 | 85 |
| 4 | 291·6360 | ·7817 | 87 | 86 | ·6996 | 889·4262 | 4 | 249·4262 | ·3004 | 86 |
| 15 | 257·8543 | ·7903 | 86 | 87 | ·6909 | 915·1258 | 15 | 215·1258 | ·3091 | 87 |
| 6 | 224·0640 | ·7989 | 86 | 87 | ·6822 | 940·8167 | 6 | 180·8167 | ·3178 | 87 |
| 7 | 190·2651 | ·8076 | 87 | 85 | ·6737 | 966·4989 | 7 | 146·4989 | ·3263 | 85 |
| 8 | 156·4575 | ·8163 | 87 | 87 | ·6650 | 116992·1726 | 8 | 112·1726 | ·3350 | 87 |
| 9 | 122·6412 | ·8249 | 86 | 86 | ·6564 | 117017·8376 | 9 | 077·8376 | ·3436 | 86 |
| 20 | 088·8163 | ·8336 | 87 | 87 | ·6477 | 043·4940 | 20 | 043·4940 | ·3523 | 87 |
| 1 | 054·9827 | ·8422 | 86 | 87 | ·6390 | 069·1417 | 1 | 87009·1417 | ·3610 | 87 |
| 2 | 89021·1405 | ·8509 | 87 | 85 | ·6305 | 094·7807 | 2 | 86974·7807 | ·3695 | 85 |
| 3 | 88987·2896 | ·8595 | 86 | 87 | ·6218 | 120·4112 | 3 | 940·4112 | ·3782 | 87 |
| 4 | 953·4301 | ·8682 | 87 | 86 | ·6132 | 146·0330 | 4 | 906·0330 | ·3868 | 86 |
| 25 | 919·5619 | ·8769 | 87 | 86 | ·6046 | 171·6462 | 25 | 871·6462 | ·3954 | 86 |
| 6 | 885·6850 | ·8855 | 86 | 87 | ·5959 | 197·2508 | 6 | 837·2508 | ·4041 | 87 |
| 7 | 851·7995 | ·8941 | 86 | 86 | ·5873 | 222·8467 | 7 | 802·8467 | ·4127 | 86 |
| 8 | 817·9054 | ·9028 | 87 | 86 | ·5787 | 248·4340 | 8 | 768·4340 | ·4213 | 86 |
| 9 | 784·0026 | ·9115 | 87 | 87 | ·5700 | 274·0127 | 9 | 734·0127 | ·4300 | 87 |
| 30 | 750·0911 | ·9201 | 86 | 86 | ·5614 | 299·5827 | 30 | 699·5827 | ·4386 | 86 |
| 1 | 716·1710 | ·9288 | 87 | 86 | ·5528 | 325·1441 | 1 | 665·1441 | ·4472 | 86 |
| 2 | 682·2422 | ·9374 | 86 | 87 | ·5441 | 350·6969 | 2 | 630·6969 | ·4559 | 87 |
| 3 | 648·3048 | ·9460 | 86 | 86 | ·5355 | 376·2410 | 3 | 596·2410 | ·4645 | 86 |
| 4 | 614·3588 | ·9547 | 87 | 86 | ·5269 | 401·7765 | 4 | 561·7765 | ·4731 | 86 |
| 35 | 580·4041 | ·9634 | 87 | 86 | ·5183 | 427·3034 | 35 | 527·3034 | ·4817 | 86 |
| 6 | 546·4407 | ·9720 | 86 | 87 | ·5096 | 452·8217 | 6 | 492·8217 | ·4904 | 87 |
| 7 | 512·4687 | ·9807 | 87 | 86 | ·5010 | 478·3313 | 7 | 458·3313 | ·4990 | 86 |
| 8 | 478·4880 | ·9893 | 86 | 86 | ·4924 | 503·8323 | 8 | 423·8323 | ·5076 | 86 |
| 9 | 444·4987 | 33·9980 | 87 | 87 | ·4837 | 529·3247 | 9 | 389·3247 | ·5163 | 87 |
| 40 | 410·5007 | | 86 | 86 | | 554·8084 | 40 | 854·8084 | | 86 |
| | | 34·0066 | | | ·4751 | | | | ·5249 | |
| 1 | 376·4941 | ·0153 | 87 | 86 | ·4665 | 580·2835 | 1 | 320·2835 | ·5335 | 86 |
| 2 | 342·4788 | ·0239 | 86 | 86 | ·4579 | 605·7500 | 2 | 285·7500 | ·5421 | 86 |
| 3 | 308·4549 | ·0325 | 86 | 87 | ·4492 | 631·2079 | 3 | 251·2079 | ·5508 | 87 |
| 4 | 274·4224 | ·0412 | 87 | 86 | ·4406 | 656·6571 | 4 | 216·6571 | ·5594 | 86 |
| 45 | 240·3812 | ·0499 | 87 | 86 | ·4320 | 682·0977 | 45 | 182·0977 | ·5680 | 86 |
| 6 | 206·3313 | ·0585 | 86 | 86 | ·4234 | 707·5297 | 6 | 147·5297 | ·5766 | 86 |
| 7 | 172·2728 | ·0671 | 86 | 87 | ·4147 | 732·9531 | 7 | 112·9531 | ·5853 | 87 |
| 8 | 138·2057 | ·0758 | 87 | 86 | ·4061 | 758·3678 | 8 | 078·3678 | ·5939 | 86 |
| 9 | 104·1299 | ·0845 | 87 | 86 | ·3975 | 783·7739 | 9 | 043·7739 | ·6025 | 86 |
| 50 | 070·0454 | ·0930 | 85 | 86 | ·3889 | 809·1714 | 50 | 86009·1714 | ·6111 | 86 |
| 1 | 035·9524 | ·1018 | 88 | 87 | ·3802 | 834·5603 | 1 | 85974·5603 | ·6198 | 87 |
| 2 | 88001·8506 | ·1104 | 86 | 86 | ·3716 | 859·9405 | 2 | 939·9405 | ·6284 | 86 |
| 3 | 87967·7402 | ·1190 | 86 | 86 | ·3630 | 885·3121 | 3 | 905·3121 | ·6370 | 86 |
| 4 | 933·6212 | ·1276 | 86 | 86 | ·3544 | 910·6751 | 4 | 870·6751 | ·6456 | 86 |
| 55 | 899·4936 | ·1363 | 87 | 86 | ·3458 | 936·0295 | 55 | 836·0295 | ·6542 | 86 |
| 6 | 865·3573 | ·1450 | 87 | 87 | ·3371 | 961·3753 | 6 | 801·3753 | ·6629 | 87 |
| 7 | 831·2123 | ·1536 | 86 | 86 | ·3285 | 117986·7124 | 7 | 766·7124 | ·6715 | 86 |
| 8 | 797·0587 | ·1622 | 86 | 86 | ·3199 | 118012·0409 | 8 | 732·0409 | ·6801 | 86 |
| 9 | 762·8965 | | 86 | 86 | | 037·3608 | 9 | 697·3608 | | |
| 60 | 87728·7257 | 34·1708 | | | 25·3113 | 118062·6721 | 60 | 85662·6721 | 34·6887 | |

## Mr. Aldis,

| 9° | ′ | −9°. | Diff. | Δ². | Δ². | Diff. |
|---|---|---|---|---|---|---|
| | | ″ | ″ | | | ″ |
| 8062·6721 | 0 | 85662·6721 | 34·6973 | 87 | 85 | 24·7863 |
| 087·9748 | 1 | 627·9748 | ·7060 | 86 | 86 | ·7777 |
| 113·2688 | 2 | 593·2688 | ·7146 | 86 | 86 | ·7691 |
| 138·5542 | 3 | 558·5542 | ·7232 | 86 | 87 | ·7604 |
| 163·8310 | 4 | 523·8310 | ·7318 | 86 | 85 | ·7519 |
| 189·0992 | 5 | 489·0992 | ·7404 | 87 | 86 | ·7433 |
| 214·3588 | 6 | 454·3588 | ·7491 | 86 | 86 | ·7347 |
| 239·6097 | 7 | 419·6097 | ·7577 | 85 | 86 | ·7261 |
| 264·8520 | 8 | 384·8520 | ·7662 | 87 | 85 | ·7176 |
| 290·0858 | 9 | 350·0858 | ·7749 | | 87 | ·7089 |
| | | | | 87 | 86 | ·7003 |
| 315·3109 | 10 | 315·3109 | ·7836 | 85 | 85 | ·6918 |
| 340·5273 | 1 | 280·5273 | ·7921 | 86 | 86 | ·6832 |
| 365·7352 | 2 | 245·7352 | ·8007 | 87 | 87 | ·6745 |
| 390·9345 | 3 | 210·9345 | ·8094 | 86 | 85 | ·6660 |
| 416·1251 | 4 | 176·1251 | ·8180 | 86 | 86 | ·6574 |
| 441·3071 | 15 | 141·3071 | ·8266 | 85 | 86 | ·6488 |
| 466·4805 | 6 | 106·4805 | ·8351 | 87 | 86 | ·6402 |
| 491·6454 | 7 | 071·6454 | ·8438 | 87 | 85 | ·6316 |
| 516·8016 | 8 | 036·8016 | ·8525 | 85 | 87 | ·6231 |
| 541·9491 | 9 | 85001·9491 | ·8610 | | | |
| | | | | 86 | 85 | ·61 |
| 567·0881 | 20 | 84967·0881 | ·8696 | 87 | 86 | ·60 |
| 592·2185 | 1 | 932·2185 | ·8783 | 85 | 86 | ·59 |
| 617·3402 | 2 | 897·3402 | ·8868 | 87 | 86 | ·58 |
| 642·4534 | 3 | 862·4534 | ·8955 | 86 | 86 | ·58 |
| 667·5579 | 4 | 827·5579 | ·9041 | 86 | 85 | ·57 |
| 692·6538 | 25 | 792·6538 | ·9127 | 86 | 86 | ·57 |
| 717·7411 | 6 | 757·7411 | ·9213 | 86 | 86 | ·56 |
| 742·8198 | 7 | 722·8198 | ·9299 | 86 | 86 | ·56 |
| 767·8899 | 8 | 687·8899 | ·9385 | 87 | 86 | ·55 |
| 792·9514 | 9 | 652·9514 | ·9472 | | | |
| | | | | 85 | 86 | |
| 818·0042 | 30 | 618·0042 | ·9557 | 86 | 85 | |
| 843·0485 | 1 | 583·0485 | ·9643 | 87 | 86 | |
| 868·0842 | 2 | 548·0842 | ·9730 | 85 | 86 | |
| 893·1112 | 3 | 513·1112 | ·9815 | 87 | 86 | |
| | 4 | 478·1297 | ·9902 | 85 | 85 | |





| −10°. | Diff. | Δ³. | Δ³. | Diff. | 11°. | ′ | −11°. | Diff. | Δ³. |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 83565·5901 | | 85 | 85 | | 121037·5704 | 0 | 81437·5704 | | 85 |
| 530·3764 | 35·2137 | 86 | 87 | 24·2715 | 061·8419 | 1 | 401·8419 | 35·7285 | 87 |
| 495·1541 | ·2223 | 86 | 85 | ·2628 | 086·1047 | 2 | 366·1047 | ·7372 | 85 |
| 459·9232 | ·2309 | 87 | 85 | ·2543 | 110·3590 | 3 | 330·3590 | ·7457 | 85 |
| 424·6836 | ·2396 | 85 | 86 | ·2458 | 134·6048 | 4 | 294·6048 | ·7542 | 86 |
| 389·4355 | ·2481 | 86 | 86 | ·2372 | 158·8420 | 5 | 258·8420 | ·7628 | 86 |
| 354·1788 | ·2567 | 86 | 86 | ·2286 | 183·0706 | 6 | 223·0706 | ·7714 | 86 |
| 318·9135 | ·2653 | 86 | 85 | ·2200 | 207·2906 | 7 | 187·2906 | ·7800 | 85 |
| 283·6396 | ·2739 | 85 | 85 | ·2115 | 231·5021 | 8 | 151·5021 | ·7885 | 85 |
| 248·3572 | ·2824 | 87 | 86 | ·2030 | 255·7051 | 9 | 115·7051 | ·7970 | 86 |
| | ·2911 | | | ·1944 | | | | ·8056 | |
| 213·0661 | | 86 | 86 | | 279·8995. | 10 | 079·8995. | | 86 |
| 177·7664 | ·2997 | 85 | 86 | ·1858 | 304·0853 | 1 | 044·0853 | ·8142 | 86 |
| 142·4582 | ·3082 | 86 | 85 | ·1772 | 328·2625 | 2 | 81008·2625 | ·8228 | 85 |
| 107·1414 | ·3168 | 87 | 86 | ·1687 | 352·4312 | 3 | 80972·4312 | ·8313 | 86 |
| 071·8159 | ·3255 | 85 | 85 | ·1601 | 376·5913 | 4 | 936·5913 | ·8399 | 85 |
| 036·4819 | ·3340 | 86 | 86 | ·1516 | 400·7429 | 15 | 900·7429 | ·8484 | 86 |
| 83001·1393 | ·3426 | 86 | 85 | ·1430 | 424·8859 | 6 | 864·8859 | ·8570 | 85 |
| 82965·7881 | ·3512 | 86 | 86 | ·1345 | 449·0204 | 7 | 829·0204 | ·8655 | 86 |
| 930·4283 | ·3598 | 85 | 85 | ·1259 | 473·1463 | 8 | 793·1463 | ·8741 | 85 |
| 895·0600 | ·3683 | 87 | 87 | ·1174 | 497·2637 | 9 | 757·2637 | ·8826 | 87 |
| | ·3770 | | | ·1087 | | | | ·8913 | |
| 859·6830 | | 85 | 85 | | 521·3724 | 20 | 721·3724 | | 85 |
| 824·2975 | ·3855 | 86 | 85 | ·1002 | 545·4726 | 1 | 685·4726 | ·8998 | 85 |
| 788·9034 | ·3941 | 86 | 86 | ·0917 | 569·5643 | 2 | 649·5643 | ·9083 | 86 |
| 753·5007 | ·4027 | 86 | 86 | ·0831 | 593·6474 | 3 | 613·6474 | ·9169 | 86 |
| 718·0894 | ·4113 | 86 | 84 | ·0745 | 617·7219 | 4 | 577·7219 | ·9255 | 84 |
| 682·6695 | ·4199 | 85 | 87 | ·0661 | 641·7880 | 25 | 541·7880 | ·9339 | 87 |
| 647·2411 | ·4284 | 86 | 85 | ·0574 | 665·8454 | 6 | 505·8454 | ·9426 | 85 |
| 611·8041 | ·4370 | 86 | 85 | ·0489 | 689·8943 | 7 | 469·8943 | ·9511 | 85 |
| 576·3585 | ·4456 | 86 | 86 | ·0404 | 713·9347 | 8 | 433·9347 | ·9596 | 86 |
| 540·9043 | ·4542 | 86 | 86 | ·0318 | 737·9665. | 9 | 397·9665. | ·9682 | 86 |
| | ·4628 | | | ·0232 | | | | ·9768 | |
| 505·4415 | | 86 | 85 | | 761·9897 | 30 | 361·9897 | | 85 |
| 469·9701 | ·4714 | 85 | 86 | ·0147 | 786·0044 | 1 | 326·0044 | ·9853 | 86 |
| 434·4902 | ·4799 | 86 | 85 | 24·0061 | 810·0105 | 2 | 290·0105 | 35·9939 | 85 |
| 399·0017 | ·4885 | 86 | 86 | 23·9976 | 834·0081 | 3 | 254·0081 | 36·0024 | 86 |
| 363·5046 | ·4971 | 86 | 85 | ·9890 | 857·9971 | 4 | 217·9971 | ·0110 | 85 |
| 327·9989 | ·5057 | 85 | 86 | ·9805 | 881·9776 | 35 | 181·9776 | ·0195 | 86 |
| 292·4847 | ·5142 | 87 | 85 | ·9719 | 905·9495 | 6 | 145·9495 | ·0281 | 85 |
| 256·9618 | ·5229 | 85 | 86 | ·9634 | 929·9129 | 7 | 109·9129 | ·0366 | 86 |
| 221·4304 | ·5314 | 86 | 85 | ·9548 | 953·8677 | 8 | 073·8677 | ·0452 | 85 |
| 185·8904 | ·5400 | 85 | 85 | ·9463 | 121977·8140 | 9 | 037·8140 | ·0537 | 85 |
| | ·5485 | | | ·9378 | | | | ·0622 | |
| 150·3419 | | 86 | 86 | | 122001·7518 | 40 | 80001·7518 | | 86 |
| 114·7848 | ·5571 | 87 | 86 | ·9292 | 025·6810 | 1 | 79965·6810 | ·0708 | 86 |
| 079·2190 | ·5658 | 85 | 85 | ·9206 | 049·6016 | 2 | 929·6016 | ·0794 | 85 |
| 043·6447 | ·5743 | 85 | 85 | ·9121 | 073·5137 | 3 | 893·5137 | ·0879 | 85 |
| 82008·0619 | ·5828 | 86 | 86 | ·9036 | 097·4173 | 4 | 857·4173 | ·0964 | 86 |
| 81972·4705. | ·5914 | 86 | 85 | ·8950 | 121·3123 | 45 | 821·3123 | ·1050 | 85 |
| 936·8705. | ·6000 | 86 | 85 | ·8865 | 145·1988 | 6 | 785·1988 | ·1135 | 85 |
| 901·2619 | ·6086 | 86 | 86 | ·8780 | 169·0768 | 7 | 749·0768 | ·1220 | 86 |
| 865·6447 | ·6172 | 85 | 86 | ·8694 | 192·9462 | 8 | 712·9462 | ·1306 | 86 |
| 830·0190 | ·6257 | 86 | 85 | ·8608 | 216·8070 | 9 | 676·8070 | ·1392 | 85 |
| | ·6343 | | | ·8523 | | | | ·1477 | |
| 794·3847 | | 86 | 86 | | 240·6593 | 50 | 640·6593 | | 86 |
| 758·7418 | ·6429 | 85 | 84 | ·8437 | 264·5030 | 1 | 604·5030 | ·1563 | 84 |
| 723·0904 | ·6514 | 86 | 86 | ·8353 | 288·3383 | 2 | 568·3383 | ·1647 | 86 |
| 687·4304 | ·6600 | 86 | 86 | ·8267 | 312·1650. | 3 | 532·1650. | ·1733 | 86 |
| 651·7618 | ·6686 | 85 | 85 | ·8181 | 335·9831 | 4 | 495·9831 | ·1819 | 85 |
| 616·0847 | ·6771 | 87 | 85 | ·8096 | 359·7927 | 55 | 459·7927 | ·1904 | 85 |
| 580·3989 | ·6858 | 85 | 86 | ·8011 | 383·5938 | 6 | 423·5938 | ·1989 | 86 |
| 544·7040 | ·6943 | 85 | 85 | ·7925 | 407·3863 | 7 | 387·3863 | ·2075 | 85 |
| 509·0018 | ·7028 | 86 | 85 | ·7840 | 431·1703 | 8 | 351·1703 | ·2160 | 85 |
| 473·2904 | ·7114 | 86 | 86 | ·7755 | 454·9458 | 9 | 314·9458 | ·2245 | 86 |
| 81437·5704 | 35·7200 | | | 23·7669 | 122478·7127 | 60 | 79278·7127 | 36·2331 | |

| 12°. | ′ | −12°. | Diff. | Δ¹. | Δ² | Diff. | |
|---|---|---|---|---|---|---|---|
| ″ | | ″ | ″ | | | ″ | |
| 22478·7127 | 0 | 79278·7127 | 36·2417 | 86 | 85 | 23·2472 | 1238 |
| 502·4710 | 1 | 242·4710 | ·2501 | 84 | 85 | ·2387 | 9 |
| 526·2209 | 2 | 206·2209 | ·2587 | 86 | 84 | ·2303 | 9 |
| 549·9622 | 3 | 169·9622 | ·2672 | 85 | 86 | ·2217 | 9 |
| 573·6950. | 4 | 133·6950. | ·2758 | 86 | 85 | ·2132 | 1239 |
| 597·4192 | 5 | 097·4192 | ·2843 | 85 | 85 | ·2047 | 1240 |
| 621·1349 | 6 | 061·1349 | ·2928 | 85 | 85 | ·1962 | 0 |
| 644·8421 | 7 | 79024·8421 | ·3013 | 85 | 85 | ·1877 | 0 |
| 668·5408 | 8 | 78988·5408 | ·3099 | 86 | 85 | ·1792 | 0 |
| 692·2309 | 9 | 952·2309 | ·3185 | 86 | 85 | ·1707 | 0 |
| 715·9124 | 10 | 915·9124 | ·3269 | 84 | 85 | ·1622 | 1 |
| 739·5855 | 1 | 879·5855 | ·3355 | 86 | 84 | ·1538 | 1 |
| 763·2500 | 2 | 843·2500 | ·3440 | 85 | 86 | ·1452 | 1 |
| 786·9060 | 3 | 806·9060 | ·3525 | 85 | 85 | ·1367 | 2 |
| 810·5535· | 4 | 770·5535· | ·3611 | 86 | 84 | ·1283 | 2 |
| 834·1924 | 15 | 734·1924 | ·3696 | 85 | 86 | ·1197 | 2 |
| 857·8228 | 6 | 697·8228 | ·3781 | 85 | 84 | ·1113 | 2 |
| 881·4447 | 7 | 661·4447 | ·3867 | 86 | 86 | ·1027 | 2 |
| 905·0580 | 8 | 625·0580 | ·3951 | 84 | 84 | ·0943 | 3 |
| 928·6629 | 9 | 588·6629 | ·4037 | 86 | 85 | ·0858 | 3 |
| 952·2592 | 20 | 552·2592 | ·4123 | 86 | 86 | ·0772 | 3 |
| 975·8469 | 1 | 515·8469 | ·4207 | 84 | 84 | ·0688 | 3 |
| 122999·4262 | 2 | 479·4262 | ·4293 | 86 | 85 | ·0603 | 4 |
| 123022·9969 | 3 | 442·9969 | ·4378 | 85 | 85 | ·0518 | 4 |
| 046·5591 | 4 | 406·5591 | ·4463 | 85 | 85 | ·0433 | 4 |
| 070·1128 | 25 | 370·1128 | ·4549 | 86 | 84 | ·0349 | 4 |
| 093·6579 | 6 | 333·6579 | ·4633 | 84 | 86 | ·0263 | 4 |
| 117·1946 | 7 | 297·1946 | ·4719 | 86 | 84 | ·0179 | 5 |
| 140·7227 | 8 | 260·7227 | ·4804 | 85 | 86 | ·0093 | 5 |
| 164·2423 | 9 | 224·2423 | ·4889 | 85 | 84 | 23·0009 | 5 |
| 187·7534 | 30 | 187·7534 | ·4975 | 86 | 85 | 22·9924 | 5 |
| 211·2559 | 1 | 151·2559 | ·5060 | 85 | 85 | ·9839 | 6 |
| 234·7499 | 2 | 114·7499 | ·5144 | 84 | 84 | ·9755 | 6 |

| − 13°. | Diff. | Δ². | Δ². | Diff. | 14°. | ′ | − 14°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 77089·1263 | 36·7528 | 85 | 85 | 22·7381 | 125268·9300 | 0 | 74868·9300 | 37·2619 | 85 |
| 052·3735 | ·7613 | 85 | 85 | ·7296 | 291·6681 | 1 | 831·6681 | ·2704 | 85 |
| 77015·6122 | ·7697 | 84 | 84 | ·7212 | 314·3977 | 2 | 794·3977 | ·2788 | 84 |
| 76978·8425. | ·7783 | 86 | 85 | ·7127 | 337·1189 | 3 | 757·1189 | ·2873 | 85 |
| 942·0642 | ·7868 | 85 | 84 | ·7043 | 359·8316 | 4 | 719·8316 | ·2957 | 84 |
| 905·2774 | ·7953 | 85 | 85 | ·6958 | 382·5359 | 5 | 682·5359 | ·3042 | 85 |
| 868·4821 | ·8038 | 85 | 85 | ·6873 | 405·2317 | 6 | 645·2317 | ·3127 | 85 |
| 831·6783 | ·8123 | 85 | 85 | ·6788 | 427·9190 | 7 | 607·9190 | ·3212 | 85 |
| 794·8660 | ·8208 | 85 | 84 | ·6704 | 450·5978 | 8 | 570·5978 | ·3296 | 84 |
| 758·0452 | ·8293 | 85 | 85 | ·6619 | 473·2682 | 9 | 533·2682 | ·3381 | 85 |
| 721·2159 | ·8378 | 85 | 84 | | 495·9301 | 10 | 495·9301 | ·3465 | 84 |
| 684·3781 | ·8462 | 84 | 85 | ·6535 | 518·5836 | 1 | 458·5836 | ·3550 | 85 |
| 647·5319 | ·8548 | 86 | 84 | ·6450 | 541·2286 | 2 | 421·2286 | ·3634 | 84 |
| 610·6771 | ·8633 | 85 | 85 | ·6366 | 563·8652 | 3 | 383·8652 | ·3719 | 85 |
| 573·8138 | ·8717 | 84 | 85 | ·6281 | 586·4933 | 4 | 346·4933 | ·3804 | 85 |
| 536·9421 | ·8803 | 86 | 84 | ·6196 | 609·1129 | 15 | 309·1129 | ·3888 | 84 |
| 500·0618 | ·8887 | 84 | 85 | ·6112 | 631·7241 | 6 | 271·7241 | ·3973 | 85 |
| 463·1731 | ·8973 | 86 | 85 | ·6027 | 654·3268 | 7 | 234·3268 | ·4058 | 85 |
| 426·2758 | ·9057 | 84 | 84 | ·5942 | 676·9210 | 8 | 196·9210 | ·4142 | 84 |
| 389·3701 | ·9142 | 85 | 84 | ·5858 | 699·5068 | 9 | 159·5068 | ·4226 | 84 |
| 352·4559 | ·9228 | 86 | 85 | ·5774 | 722·0842 | 20 | 122·0842 | ·4311 | 85 |
| 315·5331 | ·9312 | 84 | 85 | ·5689 | 744·6531 | 1 | 084·6531 | ·4396 | 85 |
| 278·6019 | ·9357 | 85 | 84 | ·5604 | 767·2135 | 2 | 047·2135 | ·4480 | 84 |
| 241·6622 | ·9482 | 85 | 85 | ·5520 | 789·7655 | 3 | 74009·7655 | ·4565 | 85 |
| 204·7140 | ·9567 | 85 | 84 | ·5435 | 812·3090 | 4 | 73972·3090 | ·4649 | 84 |
| 167·7573 | ·9651 | 84 | 85 | ·5351 | 834·8441 | 25 | 934·8441 | ·4734 | 85 |
| 130·7922 | ·9737 | 86 | 84 | ·5266 | 857·3707 | 6 | 897·3707 | ·4818 | 84 |
| 093·8185 | ·9821 | 84 | 85 | ·5182 | 879·8889 | 7 | 859·8889 | ·4903 | 85 |
| 056·8364 | ·9907 | 86 | 84 | ·5097 | 902·3986 | 8 | 822·3986 | ·4987 | 84 |
| 76019·8457 | 36·9991 | 84 | 85 | ·5013 | 924·8999 | 9 | 784·8999 | ·5072 | 85 |
| 75982·8466 | 37·0076 | 85 | 84 | ·4928 | 947·3927 | 30 | 747·3927 | ·5156 | 84 |
| 945·8390 | ·0161 | 85 | 85 | ·4844 | 969·8771 | 1 | 709·8771 | ·5241 | 85 |
| 908·8229 | ·0245 | 84 | 84 | ·4759 | 125992·3530 | 2 | 672·3530 | ·5325 | 84 |
| 871·7984 | ·0331 | 86 | 85 | ·4675 | 126014·8205 | 3 | 634·8205 | ·5410 | 85 |
| 834·7653 | ·0416 | 85 | 84 | ·4590 | 037·2795 | 4 | 597·2795 | ·5494 | 84 |
| 797·7237 | ·0500 | 84 | 84 | ·4506 | 059·7301 | 35 | 559·7301 | ·5578 | 84 |
| 760·6737 | ·0585 | 85 | 85 | ·4422 | 082·1723 | 6 | 522·1723 | ·5663 | 85 |
| 723·6152 | ·0670 | 85 | 85 | ·4337 | 104·6060 | 7 | 484·6060 | ·5748 | 85 |
| 686·5482 | ·0754 | 84 | 84 | ·4252 | 127·0312 | 8 | 447·0312 | ·5832 | 84 |
| 649·4728 | ·0840 | 86 | 84 | ·4168 | 149·4480 | 9 | 409·4480 | ·5916 | 84 |
| 612·3888 | ·0924 | 84 | 85 | ·4084 | 171·8564 | 40 | 371·8564 | ·6001 | 85 |
| 575·2964 | ·1009 | 85 | 84 | ·3999 | 194·2563 | 1 | 334·2563 | ·6085 | 84 |
| 538·1955. | ·1094 | 85 | 85 | ·3915 | 216·6478 | 2 | 296·6478 | ·6170 | 85 |
| 501·0861 | ·1179 | 85 | 84 | ·3830 | 239·0308 | 3 | 259·0308 | ·6254 | 84 |
| 463·9682 | ·1263 | 84 | 84 | ·3746 | 261·4054 | 4 | 221·4054 | ·6338 | 84 |
| 426·8419 | ·1348 | 85 | 85 | ·3662 | 283·7716 | 45 | 183·7716 | ·6423 | 85 |
| 389·7071 | ·1433 | 85 | 84 | ·3577 | 306·1293 | 6 | 146·1293 | ·6507 | 84 |
| 352·5638 | ·1518 | 85 | 85 | ·3493 | 328·4786 | 7 | 108·4786 | ·6592 | 85 |
| 315·4120 | ·1602 | 84 | 84 | ·3408 | 350·8194 | 8 | 070·8194 | ·6676 | 84 |
| 278·2518 | ·1687 | 85 | 84 | ·3324 | 373·1518 | 9 | 73033·1518 | ·6760 | 84 |
| 241·0831 | ·1772 | 85 | 84 | ·3240 | 395·4758 | 50 | 72995·4758 | ·6844 | 84 |
| 203·9059 | ·1857 | 85 | 85 | ·3156 | 417·7914 | 1 | 957·7914 | ·6929 | 85 |
| 166·7202 | ·1941 | 84 | 85 | ·3071 | 440·0985. | 2 | 920·0985. | ·7014 | 85 |
| 129·5261 | ·2026 | 85 | 83 | ·2986 | 462·3971 | 3 | 882·3971 | ·7097 | 83 |
| 092·3235. | ·2111 | 85 | 85 | ·2903 | 484·6874 | 4 | 844·6874 | ·7182 | 85 |
| 055·1124 | ·2196 | 85 | 84 | ·2818 | 506·9692 | 55 | 806·9692 | ·7266 | 84 |
| 75017·8928 | ·2280 | 84 | 85 | ·2734 | 529·2426 | 6 | 769·2426 | ·7351 | 85 |
| 74980·6648 | ·2364 | 84 | 84 | ·2649 | 551·5075. | 7 | 731·5075. | ·7435 | 84 |
| 943·4284 | ·2450 | 86 | 85 | ·2565 | 573·7640 | 8 | 693·7640 | ·7520 | 85 |
| 906·1834 | 37·2534 | 84 | 85 | ·2480 | 596·0120 | 9 | 656·0120 | 37·7603 | 83 |
| 74868·9300 | | | 83 | 22·2397 | 126618·2517 | 60 | 72618·2517 | | |

| | | | | |
|---|---|---|---|---|
| 04 | | 884.4701 | 2 | |
| 84 | .1301 | 906.6002 | 3 | |
| 84 | .1217 | 928.7219 | 4 | |
| 85 | .1133 | 950.8352 | 15 | |
| 83 | .1048 | 972.9400 | 6 | 72 |
| 85 | .0965 | 126995.0365. | 7 | 71 |
| 84 | .0880 | 127017.1245. | 8 | |
| 84 | .0796 | 039.2041 | 9 | |
| 84 | .0712 | | | |
| 84 | .0628 | 061.2753 | 20 | |
| 85 | .0543 | 083.3381 | 1 | |
| 83 | .0460 | 105.3924 | 2 | |
| 85 | .0375 | 127.4384 | 3 | |
| 84 | .0291 | 149.4759 | 5 | |
| 84 | .0207 | 171.5050. | 25 | |
| 84 | .0123 | 193.5257 | 6 | |
| 85 | 22.0038 | 215.5380 | 7 | |
| 83 | 21.9955 | 237.5418 | 8 | |
| 85 | .9870 | 259.5373 | 9 | |
| 83 | .9787 | 281.5243 | 30 | |
| 85 | .9702 | 303.5030 | 1 | |
| 83 | .9619 | 325.4732 | 2 | |
| 85 | .9534 | 347.4351 | 3 | |
| 84 | .9450 | 369.3885. | 4 | |
| 84 | .9366 | 391.3335 | 35 | |
| 84 | .9282 | 413.2701 | 6 | |
| 84 | .9198 | 435.1983 | 7 | |
| 84 | .9114. | 457.1181 | 8 | |
| 84 | .9030 | 479.0295. | 9 | |
| 84 | .8946 | 500.9325 | 40 | |
| 84 | .8862 | 522.8271 | 1 | |
| 84 | .8778 | 544.7133 | 2 | |
| 85 | .8693 | 566.5911 | 3 | |
| 83 | .8610 | 588.4604 | 4 | |
| 84 | .8526 | 610.3214 | 45 | |
| 84 | .8442 | 632.1740 | 6 | |
| 84 | .8358 | 654.0182 | 7 | |
| 84 | .8274 | 675.8540 | 8 | |
| 84 | .8190 | 697.6814 | 9 | |

| −16°. | Diff. | Δ². | Δ¹. | Diff. | 17°. | ′ | −17°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 70337·2287 | | 83 | 83 | | 129226·0076 | 0 | 68026·0076 | | 83 |
| | 38·2733 | | | 21·2247 | | | | 38·7753 | |
| 298·9554 | | 84 | 84 | | 247·2323 | 1 | 67987·2323 | | 84 |
| | ·2817 | | | ·2163 | | | | ·7837 | |
| 260·6737 | | 84 | 83 | | 268·4486 | 2 | 948·4486 | | 83 |
| | ·2901 | | | ·2080 | | | | ·7920 | |
| 222·3836 | | 84 | 83 | | 289·6566 | 3 | 909·6566 | | 83 |
| | ·2985 | | | ·1997 | | | | ·8003 | |
| 184·0851 | | 83 | 84 | | 310·8563 | 4 | 870·8563 | | 84 |
| | ·3068 | | | ·1913 | | | | ·8087 | |
| 145·7783 | | 85 | 84 | | 332·0476 | 5 | 832·0476 | | 84 |
| | ·3153 | | | ·1829 | | | | ·8171 | |
| 107·4630 | | 83 | 83 | | 353·2305. | 6 | 793·2305. | | 83 |
| | ·3236 | | | ·1746 | | | | ·8254 | |
| 069·1394 | | 84 | 83 | | 374·4051 | 7 | 754·4051 | | 83 |
| | ·3320 | | | ·1663 | | | | ·8337 | |
| 70030·8074 | | 84 | 84 | | 395·5714 | 8 | 715·5714 | | 84 |
| | ·3404 | | | ·1579 | | | | ·8421 | |
| 69992·4670 | | 84 | 83 | | 416·7293 | 9 | 676·7293 | | 83 |
| | ·3488 | | | ·1496 | | | | ·8504 | |
| 954·1182 | | 83 | 83 | | 437·8789 | 10 | 637·8789 | | 83 |
| | ·3571 | | | ·1413 | | | | ·8587 | |
| 915·7611 | | 85 | 84 | | 459·0202 | 1 | 599·0202 | | 84 |
| | ·3656 | | | ·1329 | | | | ·8671 | |
| 877·3955. | | 83 | 83 | | 480·1531 | 2 | 560·1531 | | 83 |
| | ·3739 | | | ·1246 | | | | ·8754 | |
| 839·0216 | | 84 | 83 | | 501·2777 | 3 | 521·2777 | | 83 |
| | ·3823 | | | ·1163 | | | | ·8837 | |
| 800·6393 | | 84 | 84 | | 522·3940 | 4 | 482·3940 | | 84 |
| | ·3907 | | | ·1079 | | | | ·8921 | |
| 762·2486 | | 84 | 83 | | 543·5019 | 15 | 443·5019 | | 83 |
| | ·3991 | | | ·0996 | | | | ·9004 | |
| 723·8495 | | 83 | 84 | | 564·6015. | 6 | 404·6015. | | 84 |
| | ·4074 | | | ·0912 | | | | ·9088 | |
| 685·4421 | | 84 | 83 | | 585·6927 | 7 | 365·6927 | | 83 |
| | ·4158 | | | ·0829 | | | | ·9171 | |
| 647·0263 | | 84 | 83 | | 606·7756 | 8 | 326·7756 | | 83 |
| | ·4242 | | | ·0746 | | | | ·9254 | |
| 608·6021 | | 84 | 83 | | 627·8502 | 9 | 287·8502 | | 83 |
| | ·4326 | | | ·0663 | | | | ·9337 | |
| 570·1695 | | 83 | 84 | | 648·9165 | 20 | 248·9165 | | 84 |
| | ·4409 | | | ·0579 | | | | ·9421 | |
| 531·7286 | | 84 | 83 | | 669·9744 | 1 | 209·9744 | | 83 |
| | ·4493 | | | ·0496 | | | | ·9504 | |
| 493·2793 | | 84 | 83 | | 691·0240 | 2 | 171·0240 | | 83 |
| | ·4577 | | | ·0413 | | | | ·9587 | |
| 454·8216 | | 83 | 84 | | 712·0653 | 3 | 132·0653 | | 84 |
| | ·4660 | | | ·0329 | | | | ·9671 | |
| 416·3556 | | 85 | 83 | | 733·0982 | 4 | 093·0982 | | 83 |
| | ·4745 | | | ·0246 | | | | ·9754 | |
| 377·8811 | | 83 | 83 | | 754·1228 | 25 | 054·1228 | | 83 |
| | ·4828 | | | ·0163 | | | | ·9837 | |
| 339·3983 | | 84 | 83 | | 775·1391 | 6 | 67015·1391 | | 83 |
| | ·4912 | | | 21·0080 | | | | 38·9920 | |
| 300·9071 | | 83 | 84 | | 796·1471 | 7 | 66976·1471 | | 84 |
| | ·4995 | | | 20·9996 | | | | 39·0004 | |
| 262·4076 | | 84 | 83 | | 817·1467 | 8 | 937·1467 | | 83 |
| | ·5079 | | | ·9913 | | | | ·0087 | |
| 223·8997 | | 84 | 83 | | 838·1380 | 9 | 898·1380 | | 83 |
| | ·5163 | | | ·9830 | | | | ·0170 | |
| 185·3834 | | 83 | 83 | | 859·1210 | 30 | 859·1210 | | 83 |
| | ·5246 | | | ·9747 | | | | ·0253 | |
| 146·8588 | | 84 | 84 | | 880·0957 | 1 | 820·0957 | | 84 |
| | ·5330 | | | ·9663 | | | | ·0337 | |
| 108·3258 | | 84 | 83 | | 901·0620 | 2 | 781·0620 | | 83 |
| | ·5414 | | | ·9580 | | | | ·0420 | |
| 069·7844 | | 84 | 83 | | 922·0200 | 3 | 742·0200 | | 83 |
| | ·5498 | | | ·9497 | | | | ·0503 | |
| 69031·2346 | | 83 | 83 | | 942·9697 | 4 | 702·9697 | | 83 |
| | ·5581 | | | ·9414 | | | | ·0586 | |
| 68992·6765 | | 83 | 83 | | 963·9111 | 35 | 663·9111 | | 83 |
| | ·5664 | | | ·9331 | | | | ·0669 | |
| 954·1101 | | 85 | 84 | | 129984·8442 | 6 | 624·8442 | | 84 |
| | ·5749 | | | ·9247 | | | | ·0753 | |
| 915·5352 | | 83 | 82 | | 130005·7689 | 7 | 585·7689 | | 82 |
| | ·5832 | | | ·9165 | | | | ·0835 | |
| 876·9520 | | 83 | 84 | | 026·6854 | 8 | 546·6854 | | 84 |
| | ·5915 | | | ·9081 | | | | ·0919 | |
| 838·3605. | | 84 | 83 | | 047·5935. | 9 | 507·5935. | | 83 |
| | ·5999 | | | ·8998 | | | | ·1002 | |
| 799·7606 | | 84 | 83 | | 068·4933 | 40 | 468·4933 | | 83 |
| | ·6083 | | | ·8915 | | | | ·1085 | |
| 761·1523 | | 83 | 84 | | 089·3848 | 1 | 429·3848 | | 84 |
| | ·6166 | | | ·8831 | | | | ·1169 | |
| 722·5357 | | 84 | 82 | | 110·2679 | 2 | 390·2679 | | 82 |
| | ·6250 | | | ·8749 | | | | ·1251 | |
| 683·9107 | | 84 | 84 | | 131·1428 | 3 | 351·1428 | | 84 |
| | ·6334 | | | ·8665 | | | | ·1335 | |
| 645·2773 | | 83 | 83 | | 152·0093 | 4 | 312·0093 | | 83 |
| | ·6417 | | | ·8582 | | | | ·1418 | |
| 606·6356 | | 84 | 82 | | 172·8675 | 45 | 272·8675 | | 82 |
| | ·6501 | | | ·8500 | | | | ·1500 | |
| 567·9855 | | 83 | 84 | | 193·7175. | 6 | 233·7175. | | 84 |
| | ·6584 | | | ·8416 | | | | ·1584 | |
| 529·3271 | | 84 | 84 | | 214·5591 | 7 | 194·5591 | | 84 |
| | ·6668 | | | ·8332 | | | | ·1668 | |
| 490·6603 | | 83 | 82 | | 235·3923 | 8 | 155·3923 | | 82 |
| | ·6751 | | | ·8250 | | | | ·1750 | |
| 451·9852 | | 84 | 83 | | 256·2173 | 9 | 116·2173 | | 83 |
| | ·6835 | | | ·8167 | | | | ·1833 | |
| 413·3017 | | 83 | 83 | | 277·0340 | 50 | 077·0340 | | 83 |
| | ·6918 | | | ·8084 | | | | ·1916 | |
| 374·6099 | | 84 | 83 | | 297·8424 | 1 | 66037·8424 | | 83 |
| | ·7002 | | | ·8001 | | | | ·1999 | |
| 335·9097 | | 84 | 84 | | 318·6425. | 2 | 65998·6425. | | 84 |
| | ·7086 | | | ·7917 | | | | ·2083 | |
| 297·2011 | | 83 | 82 | | 339·4342 | 3 | 959·4342 | | 82 |
| | ·7169 | | | ·7835 | | | | ·2165 | |
| 258·4842 | | 83 | 84 | | 360·2177 | 4 | 920·2177 | | 84 |
| | ·7252 | | | ·7751 | | | | ·2249 | |
| 219·7590 | | 84 | 82 | | 380·9928 | 55 | 880·9928 | | 82 |
| | ·7336 | | | ·7669 | | | | ·2331 | |
| 181·0254 | | 83 | 84 | | 401·7597 | 6 | 841·7597 | | 84 |
| | ·7419 | | | ·7585 | | | | ·2415 | |
| 142·2835. | | 84 | 83 | | 422·5182 | 7 | 802·5182 | | 83 |
| | ·7503 | | | ·7502 | | | | ·2498 | |
| 103·5332 | | 83 | 82 | | 443·2684 | 8 | 763·2684 | | 82 |
| | ·7586 | | | ·7420 | | | | ·2580 | |
| 064·7746 | | 84 | 84 | | 464·0104 | 9 | 724·0104 | | 84 |
| | 38·7670 | | | 20·7336 | | | | 39·2664 | |
| 68026·0076 | | | | | 130484·7440 | 60 | 65684·7440 | | |

18

19



| | | −18°. | Diff. | Δ°. | Δ°. | Diff. | 19°. |
|---|---|---|---|---|---|---|---|
| | | " | " | | | " | " |
| 7440 | 0 | 65684·7440 | 39·2746 | 82 | 83 | 20·2288 | 131713·602 |
| 7694 | 1 | 645·4694 | ·2830 | 84 | 82 | ·2206 | 733·831 |
| 7864 | 2 | 606·1864 | ·2913 | 83 | 83 | ·2123 | 754·052 |
| 7951 | 3 | 566·8951 | ·2995 | 82 | 82 | ·2041 | 774·264 |
| 7956 | 4 | 527·5956 | ·3079 | 84 | 82 | ·1959 | 794·468 |
| 7877 | 5 | 488·2877 | ·3161 | 82 | 83 | ·1876 | 814·664 |
| 7716 | 6 | 448·9716 | ·3244 | 83 | 83 | ·1793 | 834·852 |
| 7472 | 7 | 409·6472 | ·3328 | 84 | 82 | ·1711 | 855·031 |
| 7144 | 8 | 370·3144 | ·3410 | 82 | 83 | ·1628 | 875·202 |
| 6734 | 9 | 330·9734 | ·3493 | 83 | 82 | ·1546 | 895·365 |
| 6241 | 10 | 291·6241 | ·3576 | 83 | 82 | ·1464 | 915·520 |
| 6665. | 1 | 252·2665. | ·3659 | 83 | 83 | ·1381 | 935·666 |
| 5006 | 2 | 212·9006 | ·3742 | 83 | 82 | ·1299 | 955·804 |
| 5264 | 3 | 173·5264 | ·3825 | 83 | 83 | ·1216 | 975·934 |
| 4439 | 4 | 134·1439 | ·3908 | 83 | 82 | ·1134 | 131996·059 |
| 7531 | 15 | 094·7531 | ·3990 | 82 | 82 | ·1052 | 132016·169 |
| 3541 | 6 | 055·3541 | ·4074 | 84 | 83 | ·0969 | 036·274 |
| 9467 | 7 | 65015·9467 | ·4156 | 82 | 82 | ·0887 | 056·371 |
| 5311 | 8 | 64976·5311 | ·4239 | 83 | 82 | ·0805 | 076·460 |
| 1072 | 9 | 937·1072 | ·4322 | 83 | 83 | ·0722 | 096·540 |
| 6750. | 20 | 897·6750. | ·4405 | 83 | 83 | ·0639 | 116·612 |
| 2345. | 1 | 858·2345. | ·4488 | 83 | 81 | ·0558 | 136·676 |
| 7857 | 2 | 818·7857 | ·4570 | 82 | 83 | ·0475 | 156·732 |
| 3287 | 3 | 779·3287 | ·4654 | 84 | 82 | ·0393 | 176·780 |
| 8633 | 4 | 739·8633 | ·4736 | 82 | 83 | ·0310 | 196·819 |
| 3897 | 25 | 700·3897 | ·4819 | 83 | 81 | ·0229 | 216·850 |
| 9078 | 6 | 660·9078 | ·4902 | 83 | 83 | ·0146 | 236·873 |
| 4176 | 7 | 621·4176 | ·4984 | 82 | 83 | 20·0063 | 256·887 |
| 9192 | 8 | 581·9192 | ·5067 | 83 | 82 | 19·9981 | 276·894 |
| 4125. | 9 | 542·4125. | ·5150 | 83 | 82 | ·9899 | 296·892 |
| 8975. | 30 | 502·8975. | ·5233 | 83 | 82 | ·9817 | 316·882 |
| 3742 | 1 | 463·3742 | ·5315 | 82 | 82 | ·9735 | 336·863 |
| 8427 | 2 | 423·8427 | ·5399 | 84 | 83 | ·9652 | 356·837 |



20



| −19°. | Diff. | Δ². | Δ². | Diff. | 20°. | ′ | −20. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 63313·6029 | 39·7712 | 83 | 83 | 19·7352 | 132912·7582 | 0 | 60912·7582 | 40·2648 | 83 |
| 273·8317 | ·7794 | 82 | 81 | ·7271 | 932·4934 | 1 | 872·4934 | ·2729 | 81 |
| 234·0523 | ·7877 | 83 | 81 | ·7190 | 952·2205 | 2 | 832·2205 | ·2810 | 81 |
| 194·2646 | ·7959 | 82 | 83 | ·7107 | 971·9395. | 3 | 791·9395. | ·2893 | 83 |
| 154·4687 | ·8041 | 82 | 82 | ·7025 | 132991·6502 | 4 | 751·6502 | ·2975 | 82 |
| 114·6646 | ·8124 | 83 | 82 | ·6943 | 133011·3527 | 5 | 711·3527 | ·3057 | 82 |
| 074·8522 | ·8207 | 83 | 82 | ·6861 | 031·0470 | 6 | 671·0470 | ·3139 | 82 |
| 63035·0315. | ·8289 | 82 | 82 | ·6779 | 050·7331 | 7 | 630·7331 | ·3221 | 82 |
| 62995·2026 | ·8372 | 83 | 82 | ·6697 | 070·4110 | 8 | 590·4110 | ·3303 | 81 |
| 955·3654 | ·8454 | 82 | 81 | ·6616 | 090·0807 | 9 | 550·0807 | ·3384 | |
| 915·5200 | ·8536 | 82 | 83 | ·6533 | 109·7423 | 10 | 509·7423 | ·3467 | 83 |
| 875·6664 | ·8619 | 83 | 81 | ·6452 | 129·3956 | 1 | 469·3956 | ·3548 | 81 |
| 835·8045 | ·8701 | 82 | 83 | ·6369 | 149·0408 | 2 | 429·0408 | ·3631 | 83 |
| 795·9344 | ·8784 | 83 | 81 | ·6288 | 168·6777 | 3 | 388·6777 | ·3712 | 81 |
| 756·0560 | ·8866 | 82 | 82 | ·6206 | 188·3065. | 4 | 348·3065. | ·3794 | 82 |
| 716·1694 | ·8948 | 82 | 82 | ·6124 | 207·9271 | 15 | 307·9271 | ·3876 | 82 |
| 676·2746 | ·9031 | 83 | 82 | ·6042 | 227·5395. | 6 | 267·5395. | ·3958 | 82 |
| 636·3715 | ·9113 | 82 | 82 | ·5960 | 247·1437 | 7 | 227·1437 | ·4040 | 82 |
| 596·4602 | ·9195 | 82 | 82 | ·5878 | 266·7397 | 8 | 186·7397 | ·4122 | 82 |
| 556·5407 | ·9278 | 83 | 81 | ·5797 | 286·3275 | 9 | 146·3275 | ·4203 | 81 |
| 516·6129 | ·9361 | 83 | 82 | ·5715 | 305·9072 | 20 | 105·9072 | ·4285 | 82 |
| 476·6768 | ·9442 | 81 | 83 | ·5632 | 325·4787 | 1 | 065·4787 | ·4368 | 83 |
| 436·7326 | ·9525 | 83 | 81 | ·5551 | 345·0419 | 2 | 60025·0419 | ·4449 | 81 |
| 396·7801 | ·9607 | 82 | 81 | ·5470 | 364·5970 | 3 | 59984·5970 | ·4530 | 81 |
| 356·8194 | ·9690 | 83 | 83 | ·5387 | 384·1440 | 4 | 944·1440 | ·4613 | 83 |
| 316·8504 | ·9771 | 81 | 81 | ·5306 | 403·6827 | 25 | 903·6827 | ·4694 | 81 |
| 276·8733 | ·9854 | 83 | 82 | ·5224 | 423·2133 | 6 | 863·2133 | ·4776 | 82 |
| 236·8879 | 39·9937 | 83 | 82 | ·5142 | 442·7357 | 7 | 822·7357 | ·4858 | 82 |
| 196·8942 | 40·0019 | 82 | 81 | ·5061 | 462·2499 | 8 | 782·2499 | ·4939 | 81 |
| 156·8923 | ·0101 | 82 | 83 | ·4978 | 481·7560 | 9 | 741·7560 | ·5022 | 83 |
| 116·8822 | ·0183 | 82 | 81 | ·4897 | 501·2538 | 30 | 701·2538 | ·5103 | 81 |
| 076·8639 | ·0265 | 82 | 82 | ·4815 | 520·7435 | 1 | 660·7435 | ·5185 | 82 |
| 62036·8374 | ·0348 | 83 | 81 | ·4734 | 540·2250 | 2 | 620·2250 | ·5266 | 81 |
| 61996·8026 | ·0430 | 82 | 83 | ·4651 | 559·6984 | 3 | 579·6984 | ·5349 | 83 |
| 956·7596 | ·0512 | 82 | 81 | ·4570 | 579·1635 | 4 | 539·1635 | ·5430 | 81 |
| 916·7084 | ·0594 | 82 | 81 | ·4489 | 598·6205 | 35 | 498·6205 | ·5511 | 81 |
| 876·6490 | ·0677 | 83 | 82 | ·4407 | 618·0694 | 6 | 458·0694 | ·5593 | 82 |
| 836·5813 | ·0759 | 82 | 82 | ·4325 | 637·5101 | 7 | 417·5101 | ·5675 | 82 |
| 796·5054 | ·0841 | 82 | 82 | ·4243 | 656·9426 | 8 | 376·9426 | ·5757 | 82 |
| 756·4213 | ·0923 | 82 | 82 | ·4161 | 676·3669 | 9 | 336·3669 | ·5839 | 82 |
| 716·3290 | ·1005 | 82 | 81 | ·4080 | 695·7830 | 40 | 295·7830 | ·5920 | 81 |
| 676·2285. | ·1088 | 83 | 81 | ·3999 | 715·1910 | 1 | 255·1910 | ·6001 | 81 |
| 636·1197 | ·1169 | 81 | 82 | ·3917 | 734·5909 | 2 | 214·5909 | ·6083 | 82 |
| 596·0028 | ·1252 | 83 | 82 | ·3835 | 753·9826 | 3 | 173·9826 | ·6165 | 82 |
| 555·8776 | ·1334 | 82 | 82 | ·3753 | 773·3661 | 4 | 133·3661 | ·6247 | 82 |
| 515·7442 | ·1416 | 82 | 81 | ·3672 | 792·7414 | 45 | 092·7414 | ·6328 | 81 |
| 475·6026 | ·1498 | 82 | 82 | ·3590 | 812·1086 | 6 | 052·1086 | ·6410 | 82 |
| 435·4528 | ·1580 | 82 | 81 | ·3509 | 831·4676 | 7 | 59011·4676 | ·6491 | 81 |
| 395·2948 | ·1663 | 83 | 82 | ·3427 | 850·8185. | 8 | 58970·8185. | ·6573 | 82 |
| 355·1285 | ·1745 | 82 | 81 | ·3346 | 870·1612 | 9 | 930·1612 | ·6654 | 81 |
| 314·9540 | ·1826 | 81 | 82 | ·3264 | 889·4958 | 50 | 889·4958 | ·6736 | 82 |
| 274·7714 | ·1909 | 83 | 82 | ·3182 | 908·8222 | 1 | 848·8222 | ·6818 | 82 |
| 234·5805 | ·1990 | 81 | 81 | ·3101 | 928·1404 | 2 | 808·1404 | ·6899 | 81 |
| 194·3815. | ·2073 | 83 | 81 | ·3020 | 947·4505 | 3 | 767·4505 | ·6980 | 81 |
| 154·1742 | ·2155 | 82 | 83 | ·2937 | 966·7525. | 4 | 726·7525. | ·7063 | 83 |
| 113·9587 | ·2237 | 82 | 81 | ·2856 | 133986·0462 | 55 | 686·0462 | ·7144 | 81 |
| 073·7350. | ·2319 | 82 | 81 | ·2775 | 134005·3318 | 6 | 645·3318 | ·7225 | 81 |
| 61033·5031 | ·2401 | 82 | 82 | ·2694 | 024·6093 | 7 | 604·6093 | ·7306 | 82 |
| 60993·2630 | ·2483 | 82 | 82 | ·2612 | 043·8787 | 8 | 563·8787 | ·7388 | 82 |
| 953·0147 | 40·2565 | | 82 | 19·2530 | 063·1399 | 9 | 523·1399 | 40·7470 | |
| 60912·7582 | | | | | 134082·3929 | 60 | 58482·3929 | | |

| Δ². | Diff. | 21°. | ′ | −21°. | Diff. | Δ². |
|---|---|---|---|---|---|---|
| | ″ | ″ | | ″ | ″ | |
| 81 | | 134082·3929 | 0 | 58482·3929 | | 81 |
| | 19·2449 | | | | 40·7551 | |
| 82 | ·2367 | 101·6378 | 1 | 441·6378 | ·7633 | 82 |
| 81 | ·2286 | 120·8745 | 2 | 400·8745 | ·7714 | 81 |
| 81 | ·2205 | 140·1031 | 3 | 360·1031 | ·7795 | 81 |
| 82 | ·2123 | 159·3236 | 4 | 319·3236 | ·7877 | 82 |
| 82 | ·2041 | 178·5359 | 5 | 278·5359 | ·7959 | 82 |
| 80 | ·1961 | 197·7400 | 6 | 237·7400 | ·8039 | 80 |
| 82 | ·1879 | 216·9361 | 7 | 196·9361 | ·8121 | 82 |
| 82 | ·1797 | 236·1240 | 8 | 156·1240 | ·8203 | 82 |
| 81 | ·1716 | 255·3037 | 9 | 115·3037 | ·8284 | 81 |
| 81 | | 274·4753 | 10 | 074·4753 | | 81 |
| 82 | ·1635 | 293·6388 | 1 | 58033·6388 | ·8365 | 82 |
| 81 | ·1553 | 312·7941 | 2 | 57992·7941 | ·8447 | 81 |
| 82 | ·1472 | 331·9413 | 3 | 951·9413 | ·8528 | 82 |
| 80 | ·1390 | 351·0803 | 4 | 911·0803 | ·8610 | 80 |
| 82 | ·1310 | 370·2113 | 15 | 870·2113 | ·8690 | 82 |
| 82 | ·1228 | 389·3341 | 6 | 829·3341 | ·8772 | 82 |
| 81 | ·1146 | 408·4487 | 7 | 788·4487 | ·8854 | 81 |
| 81 | ·1065 | 427·5552 | 8 | 747·5552 | ·8935 | 81 |
| 81 | ·0984 | 446·6536 | 9 | 706·6536 | ·9016 | 81 |
| | ·0903 | | | | ·9097 | |
| 81 | | 465·7439 | 20 | 665·7439 | | 81 |
| 82 | ·0822 | 484·8261 | 1 | 624·8261 | ·9178 | 82 |
| 81 | ·0740 | 503·9001 | 2 | 583·9001 | ·9260 | 81 |
| 82 | ·0659 | 522·9660 | 3 | 542·9660 | ·9341 | 82 |
| 80 | ·0577 | 542·0237 | 4 | 502·0237 | ·9423 | 80 |
| 82 | ·0497 | 561·0734 | 25 | 461·0734 | ·9503 | 82 |
| 81 | ·0415 | 580·1149 | 6 | 420·1149 | ·9585 | 81 |
| 82 | ·0334 | 599·1483 | 7 | 379·1483 | ·9666 | 82 |
| 80 | ·0252 | 618·1735 | 8 | 338·1735 | ·9748 | 80 |
| 82 | ·0172 | 637·1907 | 9 | 297·1907 | ·9828 | 82 |
| | ·0090 | | | | ·9910 | |
| 81 | | 656·1997 | 30 | 256·1997 | | 81 |
| 81 | 19·0009 | 675·2006 | 1 | 215·2006 | 40·9991 | 81 |
| 82 | 18·9928 | 694·1934 | 2 | 174·1934 | 41·0072 | 82 |
| 80 | ·9846 | 713·1780 | 3 | 133·1780 | ·0154 | 80 |
| 82 | ·9766 | 732·1546 | 4 | 092·1546 | ·0234 | 82 |
| 81 | ·9684 | 751·1230 | 35 | 051·1230 | ·0316 | 81 |
| 81 | ·9603 | 770·0833 | 6 | 57010·0833 | ·0397 | 81 |
| 81 | ·9522 | 789·0355 | 7 | 56969·0355 | ·0478 | 81 |
| 81 | ·9441 | 807·9796 | 8 | 927·9796 | ·0559 | 81 |
| 81 | ·9360 | 826·9156 | 9 | 886·9156 | ·0640 | 81 |
| | ·9279 | | | | ·0721 | |
| 81 | | 845·8435 | 40 | 845·8435 | | 81 |
| 82 | ·9198 | 864·7633 | 1 | 804·7633 | ·0802 | 82 |
| 80 | ·9116 | 883·6749 | 2 | 763·6749 | ·0884 | 80 |
| 82 | ·9036 | 902·5785 | 3 | 722·5785 | ·0964 | 82 |
| 81 | ·8954 | 921·4739 | 4 | 681·4739 | ·1046 | 81 |
| 80 | ·8873 | 940·3612 | 45 | 640·3612 | ·1127 | 80 |
| 82 | ·8793 | 959·2405 | 6 | 599·2405 | ·1207 | 82 |
| 81 | ·8711 | 978·1116 | 7 | 558·1116 | ·1289 | 81 |
| 81 | ·8630 | 134996·9746 | 8 | 516·9746 | ·1370 | 81 |
| 81 | ·8549 | 135015·8295 | 9 | 475·8295 | ·1451 | 81 |
| | ·8468 | | | | ·1532 | |
| 81 | | 034·6763 | 50 | 434·6763 | | 81 |
| 81 | ·8387 | 053·5150 | 1 | 393·5150 | ·1613 | 81 |
| 80 | ·8306 | 072·3456 | 2 | 352·3456 | ·1694 | 80 |
| 82 | ·8226 | 091·1682 | 3 | 311·1682 | ·1774 | 82 |
| 81 | ·8144 | 109·9826 | 4 | 269·9826 | ·1856 | 81 |
| 81 | ·8063 | 128·7889 | 55 | 228·7889 | ·1937 | 81 |
| 81 | ·7982 | 147·5871 | 6 | 187·5871 | ·2018 | 81 |
| 80 | ·7901 | 166·3772 | 7 | 146·3772 | ·2099 | 80 |
| 82 | ·7821 | 185·1593 | 8 | 105·1593 | ·2179 | 82 |
| 80 | ·7739 | 203·9332 | 9 | 063·9332 | ·2261 | 80 |
| | 18·7659 | 135222·6991 | 60 | 56022·6991 | 41·2341 | |

| Δ². | Diff. | 22° |
|---|---|---|
| | ″ | ″ |
| 82 | | 135222·6991 |
| | 18·7577 | |
| 80 | | 241·4568 |
| 82 | ·7497 | 260·2065 |
| 80 | ·7415 | 278·9480 |
| 81 | ·7335 | 297·6815 |
| 80 | ·7254 | 316·4069 |
| 82 | ·7174 | 335·1243 |
| 81 | ·7092 | 353·8335 |
| 80 | ·7011 | 372·5346 |
| 81 | ·6931 | 391·2277 |
| | ·6850 | |
| 81 | | 409·9127 |
| 81 | ·6769 | 428·5896 |
| 81 | ·6688 | 447·2584 |
| 80 | ·6607 | 465·9191 |
| 81 | ·6527 | 484·5718 |
| 81 | ·6446 | 503·2164 |
| 81 | ·6365 | 521·8529 |
| 81 | ·6284 | 540·4813 |
| 80 | ·6203 | 559·1016 |
| 81 | ·6123 | 577·7139 |
| | ·6042 | |
| 80 | | 596·3181 |
| 82 | ·5962 | 614·9143 |
| 80 | ·5880 | 633·5023 |
| 81 | ·5800 | 652·0823 |
| 80 | ·5719 | 670·6542 |
| 81 | ·5639 | 689·2181 |
| 81 | ·5558 | 707·7739 |
| 80 | ·5477 | 726·3216 |
| 81 | ·5397 | 744·8613 |
| 81 | ·5316 | 763·3929 |
| | ·5235 | |
| 81 | | 781·9164 |
| 80 | ·5154 | 800·4318 |
| 80 | ·5074 | 818·9392 |
| 81 | ·4994 | 837·4386 |
| 81 | ·4913 | 855·9299 |
| 80 | ·4832 | 874·4131 |
| 81 | ·4752 | 892·8883 |
| 81 | ·4671 | 911·3554 |
| 80 | ·4590 | 929·8144 |
| 80 | ·4510 | 948·2654 |
| | ·4430 | |
| 81 | | 966·7084 |
| 81 | ·4349 | 135985·1433 |
| 80 | ·4268 | 136003·5701 |
| 80 | ·4188 | 021·9889 |
| 81 | ·4108 | 040·3997 |
| 81 | ·4027 | 058·8024 |
| 80 | ·3946 | 077·1970 |
| 80 | ·3866 | 095·5837 |
| 81 | ·3786 | 113·9622 |
| 80 | ·3705 | 132·3327 |
| | ·3625 | |
| 81 | | 150·6952 |
| 81 | ·3544 | 169·0496 |
| 79 | ·3463 | 187·3959 |
| 81 | ·3384 | 205·7343 |
| 80 | ·3303 | 224·0647 |
| 81 | ·3223 | 242·3869 |
| 80 | ·3142 | 260·7011 |
| 81 | ·3062 | 279·0073 |
| 80 | ·2981 | 297·3054 |
| 80 | ·2901 | 315·5955 |
| | 18·2821 | 136333·8776 |

| ′ | −22°. | Diff. | Δ². | Δ′. | Diff. | 23°. | ′ | −23°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|---|
| | ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 0 | 56022·6991 | | 82 | 80 | | 136333·8776 | 0 | 53533·8776 | | 80 |
| | | 41·2423 | | | 18·2741 | | | | 41·7259 | |
| 1 | 55981·4568 | | 80 | 81 | | 352·1517 | 1 | 492·1517 | | 81 |
| | | ·2503 | | | ·2660 | | | | ·7340 | |
| 2 | 940·2065. | | 82 | 80 | | 370·4177 | 2 | 450·4177 | | 80 |
| | | ·2585 | | | ·2580 | | | | ·7420 | |
| 3 | 898·9480 | | 80 | 81 | | 388·6757 | 3 | 408·6757 | | 81 |
| | | ·2665 | | | ·2499 | | | | ·7501 | |
| 4 | 857·6815 | | 81 | 79 | | 406·9256 | 4 | 366·9256 | | 79 |
| | | ·2746 | | | ·2420 | | | | ·7580 | |
| 5 | 816·4069 | | 80 | 81 | | 425·1676 | 5 | 325·1676 | | 81 |
| | | ·2826 | | | ·2339 | | | | ·7661 | |
| 6 | 775·1243 | | 82 | 81 | | 443·4015 | 6 | 283·4015 | | 81 |
| | | ·2908 | | | ·2258 | | | | ·7742 | |
| 7 | 733·8335. | | 81 | 79 | | 461·6273 | 7 | 241·6273 | | 79 |
| | | ·2989 | | | ·2179 | | | | ·7821 | |
| 8 | 692·5346 | | 80 | 81 | | 479·8452 | 8 | 199·8452 | | 81 |
| | | ·3069 | | | ·2098 | | | | ·7902 | |
| 9 | 651·2277 | | 81 | 80 | | 498·0550 | 9 | 158·0550 | | 80 |
| | | ·3150 | | | ·2018 | | | | ·7982 | |
| 10 | 609·9127 | | 81 | 80 | | 516·2568 | 10 | 116·2568 | | 80 |
| | | ·3231 | | | ·1938 | | | | ·8062 | |
| 1 | 568·5896 | | 81 | 81 | | 534·4506 | 1 | 074·4506 | | 81 |
| | | ·3312 | | | ·1857 | | | | ·8143 | |
| 2 | 527·2584 | | 81 | 79 | | 552·6363 | 2 | 53032·6363 | | 79 |
| | | ·3393 | | | ·1778 | | | | ·8222 | |
| 3 | 485·9191 | | 80 | 81 | | 570·8141 | 3 | 52990·8141 | | 81 |
| | | ·3473 | | | ·1697 | | | | ·8303 | |
| 4 | 444·5718 | | 81 | 80 | | 588·9838 | 4 | 948·9838 | | 80 |
| | | ·3554 | | | ·1617 | | | | ·8383 | |
| 15 | 403·2164 | | 81 | 81 | | 607·1455. | 15 | 907·1455. | | 81 |
| | | ·3635 | | | ·1536 | | | | ·8464 | |
| 6 | 361·8529 | | 81 | 79 | | 625·2991 | 6 | 865·2991 | | 79 |
| | | ·3716 | | | ·1457 | | | | ·4543 | |
| 7 | 320·4813 | | 81 | 81 | | 643·4448 | 7 | 823·4448 | | 81 |
| | | ·3797 | | | ·1376 | | | | ·8624 | |
| 8 | 279·1016 | | 80 | 79 | | 661·5824 | 8 | 781·5824 | | 79 |
| | | ·3877 | | | ·1297 | | | | ·8703 | |
| 9 | 237·7139 | | 81 | 81 | | 679·7121 | 9 | 739·7121 | | 81 |
| | | ·3958 | | | ·1216 | | | | ·8784 | |
| 20 | 196·3181 | | 80 | 80 | | 697·8337 | 20 | 697·8337 | | 80 |
| | | ·4038 | | | ·1136 | | | | ·8864 | |
| 1 | 154·9143 | | 82 | 80 | | 715·9473 | 1 | 655·9473 | | 80 |
| | | ·4120 | | | ·1056 | | | | ·8944 | |
| 2 | 113·5023 | | 80 | 80 | | 734·0529 | 2 | 614·0529 | | 80 |
| | | ·4200 | | | ·0976 | | | | ·9024 | |
| 3 | 072·0823 | | 81 | 81 | | 752·1505. | 3 | 572·1505. | | 81 |
| | | ·4281 | | | ·0895 | | | | ·9105 | |
| 4 | 55030·6542 | | 80 | 79 | | 770·2400 | 4 | 530·2400 | | 79 |
| | | ·4361 | | | ·0816 | | | | ·9184 | |
| 25 | 54989·2181 | | 81 | 81 | | 788·3216 | 25 | 488·3216 | | 81 |
| | | ·4442 | | | ·0735 | | | | ·9265 | |
| 6 | 947·7739 | | 81 | 79 | | 806·3951 | 6 | 446·3951 | | 79 |
| | | ·4523 | | | ·0656 | | | | ·9344 | |
| 7 | 906·3216 | | 80 | 81 | | 824·4607 | 7 | 404·4607 | | 81 |
| | | ·4603 | | | ·0575 | | | | ·9425 | |
| 8 | 864·8613 | | 81 | 80 | | 842·5182 | 8 | 362·5182 | | 80 |
| | | ·4684 | | | ·0495 | | | | ·9505 | |
| 9 | 823·3929 | | 81 | 79 | | 860·5677 | 9 | 320·5677 | | 79 |
| | | ·4765 | | | ·0416 | | | | ·9584 | |
| 30 | 781·9164 | | 81 | 81 | | 878·6093 | 30 | 278·6093 | | 81 |
| | | ·4846 | | | ·0335 | | | | ·9665 | |
| 1 | 740·4318 | | 80 | 80 | | 896·6428 | 1 | 236·6428 | | 80 |
| | | ·4926 | | | ·0255 | | | | ·9745 | |
| 2 | 698·9392 | | 80 | 79 | | 914·6683 | 2 | 194·6683 | | 79 |
| | | ·5006 | | | ·0176 | | | | ·9824 | |
| 3 | 657·4386 | | 81 | 81 | | 932·6859 | 3 | 152·6859 | | 81 |
| | | ·5087 | | | ·0095 | | | | ·9905 | |
| 4 | 615·9299 | | 81 | 80 | | 950·6954 | 4 | 110·6954 | | 80 |
| | | ·5168 | | | 18·0015 | | | | 41·9985 | |
| 35 | 574·4131 | | 80 | 80 | | 968·6969 | 35 | 068·6969 | | 80 |
| | | ·5248 | | | 17·9935 | | | | 42·0065 | |
| 6 | 532·8883 | | 81 | 79 | | 136986·6904 | 6 | 52026·6904 | | 79 |
| | | ·5329 | | | ·9856 | | | | ·0144 | |
| 7 | 491·3554 | | 81 | 81 | | 137004·6760 | 7 | 51984·6760 | | 81 |
| | | ·5410 | | | ·9775 | | | | ·0225 | |
| 8 | 449·8144 | | 80 | 80 | | 022·6535. | 8 | 942·6535. | | 80 |
| | | ·5490 | | | ·9695 | | | | ·0305 | |
| 9 | 408·2654 | | 80 | 79 | | 040·6230 | 9 | 900·6230 | | 79 |
| | | ·5570 | | | ·9616 | | | | ·0384 | |
| 40 | 366·7084 | | 81 | 81 | | 058·5846 | 40 | 858·5846 | | 81 |
| | | ·5651 | | | ·9535 | | | | ·0465 | |
| 1 | 325·1433 | | 81 | 79 | | 076·5381 | 1 | 816·5381 | | 79 |
| | | ·5732 | | | ·9456 | | | | ·0544 | |
| 2 | 283·5701 | | 80 | 80 | | 094·4837 | 2 | 774·4837 | | 80 |
| | | ·5812 | | | ·9376 | | | | ·0624 | |
| 3 | 241·9889 | | 80 | 80 | | 112·4213 | 3 | 732·4213 | | 80 |
| | | ·5892 | | | ·9296 | | | | ·0704 | |
| 4 | 200·3997 | | 81 | 80 | | 130·3509 | 4 | 690·3509 | | 80 |
| | | ·5973 | | | ·9216 | | | | ·0784 | |
| 45 | 158·8024 | | 81 | 80 | | 148·2725. | 45 | 648·2725. | | 80 |
| | | ·6054 | | | ·9136 | | | | ·0864 | |
| 6 | 117·1970 | | 80 | 80 | | 166·1861 | 6 | 606·1861 | | 80 |
| | | ·6134 | | | ·9056 | | | | ·0944 | |
| 7 | 075·5836 | | 80 | 80 | | 184·0917 | 7 | 564·0917 | | 80 |
| | | ·6214 | | | ·8976 | | | | ·1024 | |
| 8 | 54033·9622 | | 81 | 80 | | 201·9893 | 8 | 521·9893 | | 80 |
| | | ·6295 | | | ·8896 | | | | ·1104 | |
| 9 | 53992·3327 | | 80 | 79 | | 219·8789 | 9 | 479·8789 | | 79 |
| | | ·6375 | | | ·8817 | | | | ·1183 | |
| 50 | 950·6952 | | 81 | 80 | | 237·7606 | 50 | 437·7606 | | 80 |
| | | ·6456 | | | ·8737 | | | | ·1263 | |
| 1 | 909·0496 | | 81 | 80 | | 255·6343 | 1 | 395·6343 | | 80 |
| | | ·6537 | | | ·8657 | | | | ·1343 | |
| 2 | 867·3959 | | 79 | 80 | | 273·5000 | 2 | 353·5000 | | 80 |
| | | ·6616 | | | ·8577 | | | | ·1423 | |
| 3 | 825·7343 | | 81 | 79 | | 291·3577 | 3 | 311·3577 | | 79 |
| | | ·6697 | | | ·8498 | | | | ·1502 | |
| 4 | 784·0646 | | 80 | 81 | | 309·2075. | 4 | 269·2075. | | 81 |
| | | ·6777 | | | ·8417 | | | | ·1583 | |
| 55 | 742·3869 | | 81 | 79 | | 327·0492 | 55 | 227·0492 | | 79 |
| | | ·6858 | | | ·8338 | | | | ·1662 | |
| 6 | 700·7011 | | 80 | 80 | | 344·8830 | 6 | 184·8830 | | 80 |
| | | ·6938 | | | ·8258 | | | | ·1742 | |
| 7 | 659·0073 | | 81 | 79 | | 362·7088 | 7 | 142·7088 | | 79 |
| | | ·7019 | | | ·8179 | | | | ·1821 | |
| 8 | 617·3054 | | 80 | 81 | | 380·5267 | 8 | 100·5267 | | 81 |
| | | ·7099 | | | ·8098 | | | | ·1902 | |
| 9 | 575·5955 | | 80 | 79 | | 398·3365 | 9 | 058·3365 | | 79 |
| | | 41·7179 | | | 17·8019 | | | | 42·1981 | |
| 60 | 53533·8776 | | | | | 137416·1384 | 60 | 51016·1384 | | |

| | | $-z_1^3$. | Diff. | $\Delta^3$. | $\Delta^3$. | Diff. | $z_2^3$ |
|---|---|---|---|---|---|---|---|
| | | " | " | | | " | " |
| 20 | 0 | 58182·3929 | 40·7551 | 81 | 82 | 18·7577 | 135222·699 |
| 93 | 1 | 441·6378 | ·7633 | 81 | 80 | ·7497 | 241·456 |
| 45 | 2 | 400·8745 | ·7714 | 81 | 82 | ·7415 | 260·206 |
| 41 | 3 | 360·1031 | ·7795 | 81 | 80 | ·7335 | 278·948 |
| 39 | 4 | 319·3236 | ·7877 | 82 | 81 | ·7254 | 297·681 |
| 61 | 5 | 278·5359 | ·7959 | 82 | 80 | ·7174 | 316·406 |
| 80 | 6 | 237·7400 | ·8039 | 80 | 82 | ·7092 | 335·124 |
| 01 | 7 | 196·9361 | ·8121 | 82 | 81 | ·7011 | 353·833 |
| 40 | 8 | 156·1240 | ·8203 | 82 | 80 | ·6931 | 372·534 |
| 17 | 9 | 115·3037 | ·8284 | 81 | 81 | ·6850 | 391·227 |
| 54 | 10 | 074·4753 | ·8365 | 81 | 81 | ·6769 | 409·912 |
| 88 | 1 | 58033·6388 | ·8447 | 82 | 81 | ·6688 | 428·589 |
| 41 | 2 | 57992·7941 | ·8528 | 81 | 81 | ·6607 | 447·258 |
| 13 | 3 | 951·9413 | ·8610 | 82 | 80 | ·6527 | 465·919 |
| 03 | 4 | 911·0803 | ·8690 | 80 | 81 | ·6446 | 484·571 |
| 13 | 15 | 870·2113 | ·8772 | 82 | 81 | ·6365 | 503·216 |
| 41 | 6 | 829·3341 | ·8854 | 82 | 81 | ·6284 | 521·852 |
| 87 | 7 | 788·4487 | ·8935 | 81 | 81 | ·6203 | 540·481 |
| 52 | 8 | 747·5552 | ·9016 | 81 | 80 | ·6123 | 559·101 |
| 36 | 9 | 706·6536 | ·9097 | 81 | 81 | ·6042 | 577·713 |
| 30 | 20 | 665·7439 | ·9178 | 81 | 80 | ·5962 | 596·318 |
| 01 | 1 | 624·8261 | ·9260 | 82 | 82 | ·5880 | 614·914 |
| 01 | 2 | 583·9001 | ·9341 | 81 | 80 | ·5800 | 633·502 |
| 08 | 3 | 542·9660 | ·9423 | 82 | 81 | ·5719 | 652·082 |
| 37 | 4 | 502·0237 | ·9503 | 80 | 80 | ·5639 | 670·654 |
| 34 | 25 | 461·0734 | ·9585 | 82 | 81 | ·5558 | 689·218 |
| 49 | 6 | 420·1149 | ·9666 | 81 | 81 | ·5477 | 707·773 |
| 83 | 7 | 379·1483 | ·9748 | 82 | 80 | ·5397 | 726·321 |
| 35 | 8 | 338·1735 | ·9828 | 80 | 81 | ·5316 | 744·861 |
| 07 | 9 | 297·1907 | ·9910 | 82 | 81 | ·5235 | 763·392 |
| 97 | 30 | 256·1997 | 40·9991 | 81 | 81 | ·5154 | 781·916 |
| 06 | 1 | 215·2006 | 41·0072 | 81 | 80 | ·5074 | 800·431 |
| 31 | 2 | 174·1934 | ·0154 | 82 | 80 | ·4994 | 818·939 |
| 80 | 3 | 133·1780 | ·0234 | 80 | 81 | ·4913 | 837·439 |

| ′ | −22°. | Diff. | Δ². | Δ¹. | Diff. | 23°. | ′ | −23°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|---|
| | ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 0 | 56022·6991 | | 82 | | | 136333·8776 | 0 | 53533·8776 | | 80 |
| | | 41·2423 | | 80 | 18·2741 | | | | 41·7259 | |
| 1 | 55981·4568 | | 80 | 81 | | 352·1517 | 1 | 492·1517 | | 81 |
| | | ·2503 | | | ·2660 | | | | ·7340 | |
| 2 | 940·2065. | | 82 | 80 | | 370·4177 | 2 | 450·4177 | | 80 |
| | | ·2585 | | | ·2580 | | | | ·7420 | |
| 3 | 898·9480 | | 80 | 81 | | 388·6757 | 3 | 408·6757 | | 81 |
| | | ·2665 | | | ·2499 | | | | ·7501 | |
| 4 | 857·6815 | | 81 | 79 | | 406·9256 | 4 | 366·9256 | | 79 |
| | | ·2746 | | | ·2420 | | | | ·7580 | |
| 5 | 816·4069 | | 80 | 81 | | 425·1676 | 5 | 325·1676 | | 81 |
| | | ·2826 | | | ·2339 | | | | ·7661 | |
| 6 | 775·1243 | | 82 | 81 | | 443·4015 | 6 | 283·4015 | | 81 |
| | | ·2908 | | | ·2258 | | | | ·7742 | |
| 7 | 733·8335. | | 81 | 79 | | 461·6273 | 7 | 241·6273 | | 79 |
| | | ·2989 | | | ·2179 | | | | ·7821 | |
| 8 | 692·5346 | | 80 | 81 | | 479·8452 | 8 | 199·8452 | | 81 |
| | | ·3069 | | | ·2098 | | | | ·7902 | |
| 9 | 651·2277 | | 81 | 80 | | 498·0550 | 9 | 158·0550 | | 80 |
| | | ·3150 | | | ·2018 | | | | ·7982 | |
| 10 | 609·9127 | | 81 | 80 | | 516·2568 | 10 | 116·2568 | | 80 |
| | | ·3231 | | | ·1938 | | | | ·8062 | |
| 1 | 568·5896 | | 81 | 81 | | 534·4506 | 1 | 074·4506 | | 81 |
| | | ·3312 | | | ·1857 | | | | ·8143 | |
| 2 | 527·2584 | | 81 | 79 | | 552·6363 | 2 | 53032·6363 | | 79 |
| | | ·3393 | | | ·1778 | | | | ·8222 | |
| 3 | 485·9191 | | 80 | 81 | | 570·8141 | 3 | 52990·8141 | | 81 |
| | | ·3473 | | | ·1697 | | | | ·8303 | |
| 4 | 444·5718 | | 81 | 80 | | 588·9838 | 4 | 948·9838 | | 80 |
| | | ·3554 | | | ·1617 | | | | ·8383 | |
| 15 | 403·2164 | | 81 | 81 | | 607·1455. | 15 | 907·1455. | | 81 |
| | | ·3635 | | | ·1536 | | | | ·8464 | |
| 6 | 361·8529 | | 81 | 79 | | 625·2991 | 6 | 865·2991 | | 79 |
| | | ·3716 | | | ·1457 | | | | ·4543 | |
| 7 | 320·4813 | | 81 | 81 | | 643·4448 | 7 | 823·4448 | | 81 |
| | | ·3797 | | | ·1376 | | | | ·8624 | |
| 8 | 279·1016 | | 80 | 79 | | 661·5824 | 8 | 781·5824 | | 79 |
| | | ·3877 | | | ·1297 | | | | ·8703 | |
| 9 | 237·7139 | | 81 | 81 | | 679·7121 | 9 | 739·7121 | | 81 |
| | | ·3958 | | | ·1216 | | | | ·8784 | |
| 20 | 196·3181 | | 80 | 80 | | 697·8337 | 20 | 697·8337 | | 80 |
| | | ·4038 | | | ·1136 | | | | ·8864 | |
| 1 | 154·9143 | | 82 | 80 | | 715·9473 | 1 | 655·9473 | | 80 |
| | | ·4120 | | | ·1056 | | | | ·8944 | |
| 2 | 113·5023 | | 80 | 80 | | 734·0529 | 2 | 614·0529 | | 80 |
| | | ·4200 | | | ·0976 | | | | ·9024 | |
| 3 | 072·0823 | | 81 | 81 | | 752·1505. | 3 | 572·1505. | | 81 |
| | | ·4281 | | | ·0895 | | | | ·9105 | |
| 4 | 55030·6542 | | 80 | 79 | | 770·2400 | 4 | 530·2400 | | 79 |
| | | ·4361 | | | ·0816 | | | | ·9184 | |
| 25 | 54989·2181 | | 81 | 81 | | 788·3216 | 25 | 488·3216 | | 81 |
| | | ·4442 | | | ·0735 | | | | ·9265 | |
| 6 | 947·7739 | | 81 | 79 | | 806·3951 | 6 | 446·3951 | | 79 |
| | | ·4523 | | | ·0656 | | | | ·9344 | |
| 7 | 906·3216 | | 80 | 81 | | 824·4607 | 7 | 404·4607 | | 81 |
| | | ·4603 | | | ·0575 | | | | ·9425 | |
| 8 | 864·8613 | | 81 | 80 | | 842·5182 | 8 | 362·5182 | | 80 |
| | | ·4684 | | | ·0495 | | | | ·9505 | |
| 9 | 823·3929 | | 81 | 79 | | 860·5677 | 9 | 320·5677 | | 79 |
| | | ·4765 | | | ·0416 | | | | ·9584 | |
| 30 | 781·9164 | | 81 | 81 | | 878·6093 | 30 | 278·6093 | | 81 |
| | | ·4846 | | | ·0335 | | | | ·9665 | |
| 1 | 740·4318 | | 80 | 80 | | 896·6428 | 1 | 236·6428 | | 80 |
| | | ·4926 | | | ·0255 | | | | ·9745 | |
| 2 | 698·9392 | | 80 | 79 | | 914·6683 | 2 | 194·6683 | | 79 |
| | | ·5006 | | | ·0176 | | | | ·9824 | |
| 3 | 657·4386 | | 81 | 81 | | 932·6859 | 3 | 152·6859 | | 81 |
| | | ·5087 | | | ·0095 | | | | ·9905 | |
| 4 | 615·9299 | | 81 | 80 | | 950·6954 | 4 | 110·6954 | | 80 |
| | | ·5168 | | | ·0015 | | | | 41·9985 | |
| 35 | 574·4131 | | 80 | 80 | 18·0015 | 968·6969 | 35 | 068·6969 | | 80 |
| | | ·5248 | | | 17·9935 | | | | 42·0065 | |
| 6 | 532·8883 | | 81 | 79 | | 136986·6904 | 6 | 52026·6904 | | 79 |
| | | ·5329 | | | ·9856 | | | | ·0144 | |
| 7 | 491·3554 | | 81 | 81 | | 137004·6760 | 7 | 51984·6760 | | 81 |
| | | ·5410 | | | ·9775 | | | | ·0225 | |
| 8 | 449·8144 | | 80 | 80 | | 022·6535. | 8 | 942·6535. | | 80 |
| | | ·5490 | | | ·9695 | | | | ·0305 | |
| 9 | 408·2654 | | 80 | 79 | | 040·6230 | 9 | 900·6230 | | 79 |
| | | ·5570 | | | ·9616 | | | | ·0384 | |
| 40 | 366·7084 | | 81 | 81 | | 058·5846 | 40 | 858·5846 | | 81 |
| | | ·5651 | | | ·9535 | | | | ·0465 | |
| 1 | 325·1433 | | 81 | 79 | | 076·5381 | 1 | 816·5381 | | 79 |
| | | ·5732 | | | ·9456 | | | | ·0544 | |
| 2 | 283·5701 | | 80 | 80 | | 094·4837 | 2 | 774·4837 | | 80 |
| | | ·5812 | | | ·9376 | | | | ·0624 | |
| 3 | 241·9889 | | 80 | 80 | | 112·4213 | 3 | 732·4213 | | 80 |
| | | ·5892 | | | ·9296 | | | | ·0704 | |
| 4 | 200·3997 | | 81 | 80 | | 130·3509 | 4 | 690·3509 | | 80 |
| | | ·5973 | | | ·9216 | | | | ·0784 | |
| 45 | 158·8024 | | 81 | 80 | | 148·2725. | 45 | 648·2725. | | 80 |
| | | ·6054 | | | ·9136 | | | | ·0864 | |
| 6 | 117·1970 | | 80 | 80 | | 166·1861 | 6 | 606·1861 | | 80 |
| | | ·6134 | | | ·9056 | | | | ·0944 | |
| 7 | 075·5836 | | 80 | 80 | | 184·0917 | 7 | 564·0917 | | 80 |
| | | ·6214 | | | ·8976 | | | | ·1024 | |
| 8 | 54033·9622 | | 81 | 80 | | 201·9893 | 8 | 521·9893 | | 80 |
| | | ·6295 | | | ·8896 | | | | ·1104 | |
| 9 | 53992·3327 | | 80 | 79 | | 219·8789 | 9 | 479·8789 | | 79 |
| | | ·6375 | | | ·8817 | | | | ·1183 | |
| 50 | 950·6952 | | 81 | 80 | | 237·7606 | 50 | 437·7606 | | 80 |
| | | ·6456 | | | ·8737 | | | | ·1263 | |
| 1 | 909·0496 | | 81 | 80 | | 255·6343 | 1 | 395·6343 | | 80 |
| | | ·6537 | | | ·8657 | | | | ·1343 | |
| 2 | 867·3959 | | 79 | 80 | | 273·5000 | 2 | 353·5000 | | 80 |
| | | ·6616 | | | ·8577 | | | | ·1423 | |
| 3 | 825·7343 | | 81 | 79 | | 291·3577 | 3 | 311·3577 | | 79 |
| | | ·6697 | | | ·8498 | | | | ·1502 | |
| 4 | 784·0646 | | 80 | 81 | | 309·2075. | 4 | 269·2075. | | 81 |
| | | ·6777 | | | ·8417 | | | | ·1583 | |
| 55 | 742·3869 | | 81 | 79 | | 327·0492 | 55 | 227·0492 | | 79 |
| | | ·6858 | | | ·8338 | | | | ·1662 | |
| 6 | 700·7011 | | 80 | 80 | | 344·8830 | 6 | 184·8830 | | 80 |
| | | ·6938 | | | ·8258 | | | | ·1742 | |
| 7 | 659·0073 | | 81 | 79 | | 362·7088 | 7 | 142·7088 | | 79 |
| | | ·7019 | | | ·8179 | | | | ·1821 | |
| 8 | 617·3054 | | 80 | 81 | | 380·5267 | 8 | 100·5267 | | 81 |
| | | ·7099 | | | ·8098 | | | | ·1902 | |
| 9 | 575·5955 | | 80 | 79 | | 398·3365 | 9 | 058·3365 | | 79 |
| | | 41·7179 | | | 17·8019 | | | | 42·1981 | |
| 60 | 53533·8776 | | | | | 137416·1384 | 60 | 51016·1384 | | |



| | | | | |
|---|---|---|---|---|
| | 0983 | [illegible] 1393 | 2 | 509·1 |
| 79 | ·6904 | 646·8378 | 3 | 466·8 |
| 80 | ·6824 | 664·5282 | 4 | 424·5 |
| 79 | ·6745 | 682·2106 | 15 | 382·2 |
| 80 | ·6665 | 699·8851 | 6 | 339·8 |
| 80 | ·6585 | 717·5516 | 7 | 297·5 |
| 79 | ·6506 | 735·2101 | 8 | 255·2 |
| 80 | ·6426 | 752·8607 | 9 | 212·8 |
| 79 | ·6347 | 770·5033 | 20 | 170·5 |
| 79 | ·6268 | 788·1380 | 1 | 128·13 |
| 80 | ·6188 | 805·7648 | 2 | 085·76 |
| 80 | ·6108 | 823·3836 | 3 | 043·38 |
| 79 | ·6029 | 840·9944 | 4 | 50000·99 |
| 79 | ·5950 | 858·5973 | 25 | 49958·59 |
| 80 | ·5870 | 876·1923 | 6 | 916·19 |
| 80 | ·5790 | 893·7793 | 7 | 873·77 |
| 79 | ·5711 | 911·3583 | 8 | 831·35 |
| 79 | ·5632 | 928·9294 | 9 | 788·92 |
| 79 | ·5553 | 946·4926 | 30 | 746·49 |
| 80 | ·5473 | 964·0479 | 1 | 704·047 |
| 80 | ·5393 | 981·5952 | 2 | 661·595 |
| 79 | ·5314 | 137999·1345 | 3 | 619·134 |
| 79 | ·5235 | 138016·6659 | 4 | 576·665 |
| 80 | ·5155 | 034·1894 | 35 | 534·189 |
| 79 | ·5076 | 051·7049 | 6 | 491·704 |
| 79 | ·4997 | 069·2125 | 7 | 449·212 |
| 79 | ·4918 | 086·7122 | 8 | 406·712 |
| 80 | ·4838 | 104·2040 | 9 | 364·204 |
| 80 | ·4758 | 121·6878 | 40 | 321·6878 |
| 78 | ·4680 | 139·1636 | 1 | 279·1636 |
| 80 | ·4600 | 156·6316 | 2 | 236·6316 |
| 79 | ·4521 | 174·0916 | 3 | 194·0916 |
| 79 | ·4442 | 191·5437 | 4 | 151·5437 |
| 80 | ·4362 | 208·9879 | 45 | 108·9879 |
| 78 | ·4284 | 226·4241 | 6 | 066·4241 |
| 80 | ·4204 | 243·8525 | 7 | 49023·8525 |
| 80 | ·4124 | 261·2729 | 8 | 48981·2729 |
| 78 | ·4046 | 278·6853 | 9 | 938·6853 |
| 80 | ·3966 | 296·0800 | 50 | [illegible] |



25 26



| ′ | −25°. | Diff. | Δ². | Δ². | Diff. | 26°. | ′ | −26°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|---|
| | ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 0 | 48469·7000 | 42·6825 | 79 | 78 | 16·8450 | 139494·7899 | 0 | 45894·7899 | 43·1550 | 78 |
| 1 | 427·0175 | ·6904 | 79 | 79 | ·8371 | 511·6349 | 1 | 851·6349 | ·1629 | 79 |
| 2 | 384·3271 | ·6983 | 79 | 79 | ·8292 | 528·4720 | 2 | 808·4720 | ·1708 | 79 |
| 3 | 341·6288 | ·7062 | 79 | 78 | ·8214 | 545·3012 | 3 | 765·3012 | ·1786 | 78 |
| 4 | 298·9226 | ·7141 | 79 | 78 | ·8136 | 562·1226 | 4 | 722·1226 | ·1864 | 78 |
| 5 | 256·2085. | ·7221 | 80 | 79 | ·8057 | 578·9362 | 5 | 678·9362 | ·1943 | 79 |
| 6 | 213·4864 | ·7299 | 78 | 77 | ·7980 | 595·7419 | 6 | 635·7419 | ·2020 | 77 |
| 7 | 170·7565. | ·7378 | 79 | 79 | ·7901 | 612·5399 | 7 | 592·5399 | ·2099 | 79 |
| 8 | 128·0187 | ·7458 | 80 | 79 | ·7822 | 629·3300 | 8 | 549·3300 | ·2178 | 79 |
| 9 | 085·2729 | ·7536 | 78 | 78 | ·7744 | 646·1122 | 9 | 506·1122 | ·2256 | 78 |
| 10 | 48042·5193 | ·7615 | 79 | 79 | ·7665 | 662·8866 | 10 | 462·8866 | ·2335 | 79 |
| 1 | 47999·7578 | ·7695 | 80 | 77 | ·7588 | 679·6531 | 1 | 419·6531 | ·2412 | 77 |
| 2 | 956·9883 | ·7773 | 78 | 79 | ·7509 | 696·4119 | 2 | 376·4119 | ·2491 | 79 |
| 3 | 914·2110 | ·7852 | 79 | 78 | ·7431 | 713·1628 | 3 | 333·1628 | ·2569 | 78 |
| 4 | 871·4258 | ·7931 | 79 | 79 | ·7352 | 729·9059 | 4 | 289·9059 | ·2648 | 79 |
| 15 | 828·6327 | ·8010 | 79 | 78 | ·7274 | 746·6411 | 15 | 246·6411 | ·2726 | 78 |
| 6 | 785·8317 | ·8089 | 79 | 78 | ·7196 | 763·3685 | 6 | 203·3685 | ·2804 | 78 |
| 7 | 743·0228 | ·8168 | 79 | 78 | ·7118 | 780·0881 | 7 | 160·0881 | ·2882 | 78 |
| 8 | 700·2060 | ·8247 | 79 | 78 | ·7040 | 796·7999 | 8 | 116·7999 | ·2960 | 78 |
| 9 | 657·3813 | ·8326 | 79 | 79 | ·6961 | 813·5039 | 9 | 073·5039 | ·3039 | 79 |
| 20 | 614·5487 | ·8405 | 79 | 78 | ·6883 | 830·2000 | 20 | 45030·2000 | ·3117 | 78 |
| 1 | 571·7082 | ·8483 | 78 | 78 | ·6805 | 846·8883 | 1 | 44986·8883 | ·3195 | 78 |
| 2 | 528·8599 | ·8562 | 79 | 78 | ·6727 | 863·5688 | 2 | 943·5688 | ·3273 | 78 |
| 3 | 486·0037 | ·8641 | 79 | 79 | ·6648 | 880·2415 | 3 | 900·2415 | ·3352 | 79 |
| 4 | 443·1396 | ·8720 | 79 | 77 | ·6571 | 896·9063 | 4 | 856·9063 | ·3429 | 77 |
| 25 | 400·2676 | ·8799 | 79 | 79 | ·6492 | 913·5634 | 25 | 813·5634 | ·3508 | 79 |
| 6 | 357·3877 | ·8878 | 79 | 78 | ·6414 | 930·2126 | 6 | 770·2126 | ·3586 | 78 |
| 7 | 314·4999 | ·8956 | 78 | 78 | ·6336 | 946·8540 | 7 | 726·8540 | ·3664 | 78 |
| 8 | 271·6043 | ·9035 | 79 | 78 | ·6258 | 963·4876 | 8 | 683·4876 | ·3742 | 78 |
| 9 | 228·7008 | ·9114 | 79 | 78 | ·6180 | 980·1134 | 9 | 640·1134 | ·3820 | 78 |
| 30 | 185·7894 | ·9193 | 79 | 79 | ·6101 | 139996·7314 | 30 | 596·7314 | ·3899 | 79 |
| 1 | 142·8701 | ·9271 | 78 | 77 | ·6024 | 140013·3415 | 1 | 553·3415 | ·3976 | 77 |
| 2 | 099·9430 | ·9350 | 79 | 79 | ·5945 | 029·9439 | 2 | 509·9439 | ·4055 | 79 |
| 3 | 057·0080 | ·9429 | 79 | 78 | ·5867 | 046·5384 | 3 | 466·5384 | ·4133 | 78 |
| 4 | 47014·0651 | ·9508 | 79 | 77 | ·5790 | 063·1251 | 4 | 423·1251 | ·4210 | 77 |
| 35 | 46971·1143 | ·9586 | 78 | 79 | ·5711 | 079·7041 | 35 | 379·7041 | ·4289 | 79 |
| 6 | 928·1557 | ·9665 | 79 | 78 | ·5633 | 096·2752 | 6 | 336·2752 | ·4367 | 78 |
| 7 | 885·1892 | ·9744 | 79 | 78 | ·5555 | 112·8385 | 7 | 292·8385 | ·4445 | 78 |
| 8 | 842·2148 | ·9823 | 79 | 77 | ·5478 | 129·3940 | 8 | 249·3940 | ·4522 | 77 |
| 9 | 799·2325 | ·9901 | 78 | 79 | ·5399 | 145·9418 | 9 | 205·9418 | ·4601 | 79 |
| 40 | 756·2424 | 42·9080 | 79 | 78 | ·5321 | 162·4817 | 40 | 162·4817 | ·4679 | 78 |
| 1 | 713·2444 | 43·0058 | 78 | 77 | ·5244 | 179·0138 | 1 | 119·0138 | ·4756 | 77 |
| 2 | 670·2386 | ·0137 | 79 | 79 | ·5165 | 195·5382 | 2 | 075·5382 | ·4835 | 79 |
| 3 | 627·2249 | ·0216 | 79 | 78 | ·5087 | 212·0547 | 3 | 44032·0547 | ·4913 | 78 |
| 4 | 584·2033 | ·0294 | 78 | 77 | ·5010 | 228·5634 | 4 | 43988·5634 | ·4990 | 77 |
| 45 | 541·1739 | ·0373 | 79 | 79 | ·4931 | 245·0644 | 45 | 945·0644 | ·5069 | 79 |
| 6 | 498·1366 | ·0451 | 78 | 77 | ·4854 | 261·5575 | 6 | 901·5575 | ·5146 | 77 |
| 7 | 455·0915. | ·0530 | 79 | 78 | ·4776 | 278·0429 | 7 | 858·0429 | ·5224 | 78 |
| 8 | 412·0385. | ·0609 | 79 | 79 | ·4697 | 294·5205. | 8 | 814·5205. | ·5303 | 79 |
| 9 | 368·9776 | ·0687 | 78 | 77 | ·4620 | 310·9902 | 9 | 770·9902 | ·5380 | 77 |
| 50 | 325·9089 | ·0766 | 79 | 78 | ·4542 | 327·4522 | 50 | 727·4522 | ·5458 | 78 |
| 1 | 282·8323 | ·0844 | 78 | 78 | ·4464 | 343·9064 | 1 | 683·9064 | ·5536 | 78 |
| 2 | 239·7479 | ·0923 | 79 | 77 | ·4387 | 360·3528 | 2 | 640·3528 | ·5613 | 77 |
| 3 | 196·6556 | ·1001 | 78 | 79 | ·4308 | 376·7915. | 3 | 596·7915. | ·5692 | 79 |
| 4 | 153·5555. | ·1080 | 79 | 77 | ·4231 | 393·2223 | 4 | 553·2223 | ·5769 | 77 |
| 55 | 110·4475. | ·1158 | 78 | 78 | ·4153 | 409·6454 | 55 | 509·6454 | ·5847 | 78 |
| 6 | 067·3317 | ·1237 | 79 | 78 | ·4075 | 426·0607 | 6 | 466·0607 | ·5925 | 78 |
| 7 | 46024·2080 | ·1315 | 78 | 78 | ·3997 | 442·4682 | 7 | 422·4682 | ·6003 | 78 |
| 8 | 45981·0765. | ·1394 | 79 | 77 | ·3920 | 458·8679 | 8 | 378·8679 | ·6080 | 77 |
| 9 | 937·9371 | 43·1472 | 78 | 79 | 16·3841 | 475·2599 | 9 | 335·2599 | 43·6159 | 79 |
| 60 | 45894·7899 | | | | | 140491·6440 | 60 | 43291·6440 | | |

| Δ². | Diff. | 27°. | ° | ′ | −27°. | Diff. | Δ². | Δ². | Diff. | 28°. |
|---|---|---|---|---|---|---|---|---|---|---|
| | ″ | ″ | | | ″ | ″ | | | ″ | ″ |
| 77 | 16·3764 | 140491·6440 | 0 | | 43291·6440 | 43·6236 | 77 | 77 | 15·9120 | 141460·5071 |
| 77 | ·3687 | 508·0204 | 1 | | 248·0204 | ·6313 | 77 | 77 | ·9043 | 476·4191 |
| 79 | ·3608 | 524·3891 | 2 | | 204·3891 | ·6392 | 79 | 77 | ·8966 | 492·3234 |
| 77 | ·3531 | 540·7499 | 3 | | 160·7499 | ·6469 | 77 | 77 | ·8889 | 508·2200 |
| 78 | ·3453 | 557·1030 | 4 | | 117·1030 | ·6547 | 78 | 77 | ·8812 | 524·1089 |
| 78 | ·3375 | 573·4483 | 5 | | 073·4483 | ·6625 | 78 | 77 | ·8735 | 539·9901 |
| 77 | ·3298 | 589·7858 | 6 | | 43029·7858 | ·6702 | 77 | 77 | ·8658 | 555·8636 |
| 78 | ·3220 | 606·1156 | 7 | | 42986·1156 | ·6780 | 78 | 78 | ·8580 | 571·7294 |
| 78 | ·3142 | 622·4376 | 8 | | 942·4376 | ·6858 | 78 | 76 | ·8504 | 587·5874 |
| 77 | ·3065 | 638·7518 | 9 | | 898·7518 | ·6935 | 77 | 77 | ·8427 | 603·4378 |
| 78 | ·2987 | 655·0583 | 10 | | 855·0583 | ·7013 | 78 | 77 | ·8350 | 619·2805 |
| 77 | ·2910 | 671·3570 | 1 | | 811·3570 | ·7090 | 77 | 76 | ·8274 | 635·1155 |
| 79 | ·2831 | 687·6480 | 2 | | 767·6480 | ·7169 | 79 | 78 | ·8196 | 650·9429 |
| 77 | ·2754 | 703·9311 | 3 | | 723·9311 | ·7246 | 77 | 77 | ·8119 | 666·7625 |
| 77 | ·2677 | 720·2065 | 4 | | 680·2065 | ·7323 | 77 | 76 | ·8043 | 682·5744 |
| 78 | ·2599 | 736·4742 | 15 | | 636·4742 | ·7401 | 78 | 77 | ·7966 | 698·3787 |
| 77 | ·2522 | 752·7341 | 6 | | 592·7341 | ·7478 | 77 | 77 | ·7889 | 714·1753 |
| 78 | ·2444 | 768·9863 | 7 | | 548·9863 | ·7556 | 78 | 77 | ·7812 | 729·9642 |
| 78 | ·2366 | 785·2307 | 8 | | 505·2307 | ·7634 | 78 | 77 | ·7735 | 745·7454 |
| 77 | ·2289 | 801·4673 | 9 | | 461·4673 | ·7711 | 77 | 77 | ·7658 | 761·5189 |
| 78 | ·2211 | 817·6962 | 20 | | 417·6962 | ·7789 | 78 | 76 | ·7582 | 777·2847 |
| 77 | ·2134 | 833·9173 | 1 | | 373·9173 | ·7866 | 77 | 78 | ·7504 | 793·0429 |
| 78 | ·2056 | 850·1307 | 2 | | 330·1307 | ·7944 | 78 | 76 | ·7428 | 808·7933 |
| 77 | ·1979 | 866·3363 | 3 | | 286·3363 | ·8021 | 77 | 77 | ·7351 | 824·5361 |
| 78 | ·1901 | 882·5342 | 4 | | 242·5342 | ·8099 | 78 | 76 | ·7275 | 840·2712 |
| 77 | ·1824 | 898·7243 | 25 | | 198·7243 | ·8176 | 77 | 78 | ·7197 | 855·9987 |
| 78 | ·1746 | 914·9067 | 6 | | 154·9067 | ·8254 | 78 | 76 | ·7121 | 871·7184 |
| 77 | ·1669 | 931·0813 | 7 | | 111·0813 | ·8331 | 77 | 77 | ·7044 | 887·4305· |
| 77 | ·1592 | 947·2482 | 8 | | 067·2482 | ·8408 | 77 | 76 | ·6968 | 903·1349 |
| 78 | ·1514 | 963·4074 | 9 | | 42023·4074 | ·8486 | 78 | 78 | ·6890 | 918·8317 |
| 77 | ·1437 | 979·5588 | 30 | | 41979·5588 | ·8563 | 77 | 76 | ·6814 | 934·5207 |
| 78 | ·1359 | 140995·7025· | 1 | | 935·7025· | ·8641 | 78 | 76 | ·6738 | 950·2021 |
| 77 | ·1282 | 141011·8384 | 2 | | 891·8384 | ·8718 | 77 | 78 | ·6660 | 965·8759 |
| 77 | ·1205 | 027·9666 | 3 | | 847·9666 | ·8795 | 77 | 76 | ·6584 | 981·5419 |
| 78 | ·1127 | 044·0871 | 4 | | 804·0871 | ·8873 | 78 | 76 | ·6508 | 141997·2003 |
| 77 | ·1050 | 060·1998 | 35 | | 760·1998 | ·8950 | 77 | 77 | ·6431 | 142012·8511 |
| 78 | ·0972 | 076·3048 | 6 | | 716·3048 | ·9028 | 78 | 77 | ·6354 | 028·4942 |
| 76 | ·0896 | 092·4020 | 7 | | 672·4020 | ·9104 | 76 | 77 | ·6277 | 044·1296 |
| 78 | ·0818 | 108·4916 | 8 | | 628·4916 | ·9182 | 78 | 76 | ·6201 | 059·7573 |
| 78 | ·0740 | 124·5734 | 9 | | 584·5734 | ·9260 | 78 | 77 | ·6124 | 075·3774 |
| 77 | ·0663 | 140·6474 | 40 | | 540·6474 | ·9337 | 77 | 76 | ·6048 | 090·9898 |
| 77 | ·0586 | 156·7137 | 1 | | 496·7137 | ·9414 | 77 | 76 | ·5972 | 106·5946 |
| 77 | ·0509 | 172·7723 | 2 | | 452·7723 | ·9491 | 77 | 78 | ·5894 | 122·1918 |
| 77 | ·0432 | 188·8232 | 3 | | 408·8232 | ·9568 | 77 | 76 | ·5818 | 137·7812 |
| 78 | ·0354 | 204·8664 | 4 | | 364·8664 | ·9646 | 78 | 76 | ·5742 | 153·3630 |
| 77 | ·0277 | 220·9018 | 45 | | 320·9018 | ·9723 | 77 | 77 | ·5665 | 168·9372 |
| 77 | ·0200 | 236·9295. | 6 | | 276·9295. | ·9800 | 77 | 76 | ·5589 | 184·5037 |
| 78 | ·0122 | 252·9495. | 7 | | 232·9495. | ·9878 | 78 | 77 | ·5512 | 200·0626 |
| 77 | 16·0045 | 268·9617 | 8 | | 188·9617 | 43·9955 | 77 | 76 | ·5436 | 215·6138 |
| 76 | 15·9969 | 284·9662 | 9 | | 144·9662 | 44·0031 | 76 | 77 | ·5359 | 231·1574 |
| 78 | ·9891 | 300·9631 | 50 | | 100·9631 | ·0109 | 78 | 77 | ·5282 | 246·6933 |
| 77 | ·9814 | 316·9522 | 1 | | 056·9522 | ·0186 | 77 | 76 | ·5206 | 262·2215 |
| 77 | ·9737 | 332·9336 | 2 | | 41012·9336 | ·0263 | 77 | 76 | ·5130 | 277·7421 |
| 78 | ·9659 | 348·9073 | 3 | | 40968·9073 | ·0341 | 78 | 76 | ·5054 | 293·2551 |
| 76 | ·9583 | 364·8732 | 4 | | 924·8732 | ·0417 | 76 | 77 | ·4977 | 308·7605 |
| 78 | ·9505 | 380·8315. | 55 | | 880·8315. | ·0495 | 78 | 76 | ·4901 | 324·2582 |
| 77 | ·9428 | 396·7820 | 6 | | 836·7820 | ·0572 | 77 | 77 | ·4824 | 339·7483 |
| 77 | ·9351 | 412·7248 | 7 | | 792·7248 | ·0649 | 77 | 76 | ·4748 | 355·2307 |
| 76 | ·9275 | 428·6599 | 8 | | 748·6599 | ·0725 | 76 | 76 | ·4672 | 370·7055 |
| 78 | 15·9197 | 444·5874 | 9 | | 704·5874 | 44·0803 | 78 | 77 | 15·4595 | 386·1727 |
| | | 141460·5071 | 60 | | 40660·5071 | | | | | 142401·6322 |



28 29



| −28°. | Diff. | Δ². | Δ³. | Diff. | 29°. | ′ | −29°. | Diff. | Δ³. |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 40660·5071 | 44·0880 | 77 | 76 | 15·4519 | 142401·6322 | 0 | 38001·6322 | 44·5481 | 76 |
| 616·4191 | ·0957 | 77 | 76 | ·4443 | 417·0841 | 1 | 37957·0841 | ·5557 | 76 |
| 572·3234 | ·1034 | 77 | 77 | ·4366 | 432·5284 | 2 | 912·5284 | ·5634 | 77 |
| 528·2200 | ·1111 | 77 | 76 | ·4290 | 447·9650 | 3 | 867·9650 | ·5710 | 76 |
| 484·1089 | ·1188 | 77 | 76 | ·4214 | 463·3940 | 4 | 823·3940 | ·5786 | 76 |
| 439·9901 | ·1265 | 77 | 77 | ·4137 | 478·8154 | 5 | 778·8154 | ·5863 | 77 |
| 395·8636 | ·1342 | 77 | 75 | ·4062 | 494·2291 | 6 | 734·2291 | ·5938 | 75 |
| 351·7294 | ·1420 | 78 | 77 | ·3985 | 509·6353 | 7 | 689·6353 | ·6015 | 77 |
| 307·5874 | ·1496 | 76 | 76 | ·3909 | 525·0338 | 8 | 645·0338 | ·6091 | 76 |
| 263·4378 | ·1573 | 77 | 77 | ·3832 | 540·4247 | 9 | 600·4247 | ·6168 | 77 |
| 219·2805 | ·1650 | 77 | 76 | ·3756 | 555·8079 | 10 | 555·8079 | ·6244 | 76 |
| 175·1155 | ·1726 | 76 | 75 | ·3681 | 571·1835 | 1 | 511·1835 | ·6319 | 75 |
| 130·9429 | ·1804 | 78 | 77 | ·3604 | 586·5516 | 2 | 466·5516 | ·6396 | 79 |
| 086·7625 | ·1881 | 77 | 76 | ·3528 | 601·9120 | 3 | 421·9120 | ·6472 | 76 |
| 40042·5744 | ·1957 | 76 | 77 | ·3451 | 617·2648 | 4 | 377·2648 | ·6549 | 77 |
| 39998·3787 | ·2034 | 77 | 75 | ·3376 | 632·6099 | 15 | 332·6099 | ·6624 | 75 |
| 954·1753 | ·2111 | 77 | 77 | ·3299 | 647·9475· | 6 | 287·9475· | ·6701 | 77 |
| 909·9642 | ·2188 | 77 | 75 | ·3224 | 663·2774 | 7 | 243·2774 | ·6776 | 75 |
| 865·7454 | ·2265 | 77 | 77 | ·3147 | 678·5998 | 8 | 198·5998 | ·6853 | 77 |
| 821·5189 | ·2342 | 77 | 76 | ·3071 | 693·9145· | 9 | 153·9145· | ·6929 | 76 |
| 777·2847 | ·2418 | 76 | 76 | ·2995 | 709·2216 | 20 | 109·2216 | ·7005 | 76 |
| 733·0429 | ·2496 | 78 | 76 | ·2919 | 724·5211 | 1 | 064·5211 | ·7081 | 76 |
| 688·7933 | ·2572 | 76 | 76 | ·2843 | 739·8130 | 2 | 37019·8130 | ·7157 | 76 |
| 644·5361 | ·2649 | 77 | 76 | ·2767 | 755·0973 | 3 | 36975·0973 | ·7233 | 76 |
| 600·2712 | ·2725 | 76 | 76 | ·2691 | 770·3740 | 4 | 930·3740 | ·7309 | 76 |
| 555·9987 | ·2803 | 78 | 77 | ·2614 | 785·6431 | 25 | 885·6431 | ·7386 | 77 |
| 511·7184 | ·2879 | 76 | 75 | ·2539 | 800·9045 | 6 | 840·9045 | ·7461 | 75 |
| 467·4305· | ·2956 | 77 | 76 | ·2463 | 816·1584 | 7 | 796·1584 | ·7537 | 76 |
| 423·1349 | ·3032 | 76 | 76 | ·2387 | 831·4047 | 8 | 751·4047 | ·7613 | 76 |
| 378·8317 | ·3110 | 78 | 76 | ·2311 | 846·6434 | 9 | 706·6434 | ·7689 | 76 |
| 334·5207 | ·3186 | 76 | 76 | ·2235 | 861·8745 | 30 | 661·8745 | ·7765 | 76 |
| 290·2021 | ·3262 | 76 | 76 | ·2159 | 877·0980 | 1 | 617·0980 | ·7841 | 76 |
| 245·8759 | ·3340 | 78 | 76 | ·2083 | 892·3139 | 2 | 572·3139 | ·7917 | 76 |
| 201·5419 | ·3416 | 76 | 76 | ·2007 | 907·5222 | 3 | 527·5222 | ·7993 | 76 |
| 157·2003 | ·3492 | 76 | 76 | ·1931 | 922·7229 | 4 | 482·7229 | ·8069 | 76 |
| 112·8511 | ·3569 | 77 | 75 | ·1856 | 937·9160 | 35 | 437·9160 | ·8144 | 75 |
| 068·4942 | ·3646 | 77 | 77 | ·1779 | 953·1016 | 6 | 393·1016 | ·8221 | 77 |
| 39024·1296 | ·3723 | 77 | 75 | ·1704 | 968·2795 | 7 | 348·2795 | ·8296 | 75 |
| 38979·7573 | ·3799 | 76 | 76 | ·1628 | 983·4499 | 8 | 303·4499 | ·8372 | 76 |
| 935·3774 | ·3876 | 77 | 76 | ·1552 | 142998·6127 | 9 | 258·6127 | ·8448 | 76 |
| 890·9898 | ·3952 | 76 | 76 | ·1476 | 143013·7679 | 40 | 213·7679 | ·8524 | 76 |
| 846·5946 | ·4028 | 76 | 76 | ·1400 | 028·9155· | 1 | 168·9155· | ·8600 | 76 |
| 802·1918 | ·4106 | 78 | 75 | ·1325 | 044·0555 | 2 | 124·0555 | ·8675 | 75 |
| 757·7812 | ·4182 | 76 | 77 | ·1248 | 059·1880 | 3 | 079·1880 | ·8752 | 77 |
| 713·3630 | ·4258 | 76 | 75 | ·1173 | 074·3128 | 4 | 36034·3128 | ·8827 | 75 |
| 668·9372 | ·4335 | 77 | 76 | ·1097 | 089·4301 | 45 | 35989·4301 | ·8903 | 76 |
| 624·5037 | ·4411 | 76 | 75 | ·1022 | 104·5398 | 6 | 944·5398 | ·8978 | 75 |
| 580·0626 | ·4488 | 77 | 77 | ·0945 | 119·6420 | 7 | 899·6420 | ·9055 | 77 |
| 535·6138 | ·4564 | 76 | 75 | ·0870 | 134·7365 | 8 | 854·7365 | ·9130 | 75 |
| 491·1574 | ·4641 | 77 | 75 | ·0795 | 149·8235 | 9 | 809·8235 | ·9205 | 75 |
| 446·6933 | ·4718 | 77 | 77 | ·0718 | 164·9030 | 50 | 764·9030 | ·9282 | 77 |
| 402·2215 | ·4794 | 76 | 75 | ·0643 | 179·9748 | 1 | 719·9748 | ·9357 | 75 |
| 357·7421 | ·4870 | 76 | 76 | ·0567 | 195·0391 | 2 | 675·0391 | ·9433 | 76 |
| 313·2551 | ·4946 | 76 | 75 | ·0492 | 210·0958 | 3 | 630·0958 | ·9508 | 75 |
| 268·7605 | ·5023 | 77 | 76 | ·0416 | 225·1450· | 4 | 585·1450· | ·9584 | 76 |
| 224·2582 | ·5099 | 76 | 76 | ·0340 | 240·1866 | 55 | 540·1866 | ·9660 | 76 |
| 179·7485 | ·5176 | 77 | 76 | ·0264 | 255·2206 | 6 | 495·2206 | ·9736 | 76 |
| 135·2307 | ·5252 | 76 | 75 | ·0189 | 270·2470 | 7 | 450·2470 | ·9811 | 75 |
| 090·7055 | ·5328 | 76 | 75 | ·0114 | 285·2659 | 8 | 405·2659 | ·9886 | 75 |
| 046·1727 | 44·5405 | 77 | 76 | 15·0038 | 300·2773 | 9 | 360·2773 | 44·9962 | 76 |
| 38001·6322 | | | | | 143315·2811 | 60 | 35315·2811 | | |



| | | | | |
|---|---|---|---|---|
| | 9050 | 479.7373 | 2 | |
| 75 | .8981 | 509.6429 | 3 | |
| 75 | .8906 | 524.5410 | 4 | |
| 76 | .8830 | 539.4316 | 15 | |
| 76 | .8754 | 554.3146 | 6 | |
| 74 | .8680 | 569.1900 | 7 | |
| 76 | .8604 | 584.0580 | 8 | |
| 76 | .8528 | 598.9184 | 9 | 4 |
| 74 | .8454 | 613.7712 | 20 | 4 |
| 76 | .8378 | 628.6166 | 1 | 3 |
| 75 | .8303 | 643.4544 | 2 | 3 |
| 76 | .8227 | 658.2847 | 3 | 2 |
| 75 | .8152 | 673.1074 | 4 | 2 |
| 75 | .8077 | 687.9226 | 25 | 1 |
| 75 | .8002 | 702.7303 | 6 | 1 |
| 75 | .7927 | 717.5305 | 7 | 0 |
| 76 | .7851 | 732.3232 | 8 | 0 |
| 75 | .7776 | 747.1083 | 9 | 3400 |
| 75 | .7701 | 761.8859 | 30 | 3396 |
| 75 | .7626 | 776.6560 | 1 | 91 |
| 76 | .7550 | 791.4186 | 2 | 87 |
| 74 | .7476 | 806.1736 | 3 | 82 |
| 76 | .7400 | 820.9212 | 4 | 78 |
| 75 | .7325 | 835.6612 | 35 | 73 |
| 75 | .7250 | 850.3937 | 6 | 69 |
| 75 | .7175 | 865.1187 | 7 | 645 |
| 75 | .7100 | 879.8362 | 8 | 599 |
| 75 | .7025 | 894.5462 | 9 | 554 |
| 76 | .6949 | 909.2487 | 40 | 509 |
| 74 | .6875 | 923.9436 | 1 | 463 |
| 75 | .6800 | 938.6311 | 2 | 418 |
| 76 | .6724 | 953.3111 | 3 | 373 |
| 74 | .6650 | 967.9835 | 4 | 327 |
| 76 | .6574 | 982.6485. | 45 | 282 |
| 74 | .6500 | 143997.3059 | 6 | 237 |
| 76 | .6424 | 144011.9559 | 7 | 191 |
| 74 | .6350 | 026.5983 | 8 | 146 |
| 75 | .6275 | 041.2333 | 9 | 101 |
| 75 | [illegible] | 055.8608 | [illegible] | |



31 32



| −31°. | Diff. | Δ². | Δ². | Diff. | 32°. | ′ | −32°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 32601·7236 | | | | | 145061·2381 | 0 | 29861·2381 | | |
| | 45·4549 | 75 | 74 | 14·0987 | | | | 45·9013 | 74 |
| 556·2687 | ·4624 | 75 | 73 | ·0914 | 075·3368 | 1 | 815·3368 | ·9086 | 73 |
| 510·8063 | ·4698 | 74 | 75 | ·0839 | 089·4282 | 2 | 769·4282 | ·9161 | 75 |
| 465·3365 | ·4773 | 75 | 74 | ·0765 | 103·5121 | 3 | 723·5121 | ·9235 | 74 |
| 419·8592 | ·4848 | 75 | 73 | ·0692 | 117·5886 | 4 | 677·5886 | ·9308 | 73 |
| 374·3744 | ·4923 | 75 | 75 | ·0617 | 131·6578 | 5 | 631·6578 | ·9383 | 75 |
| 328·8821 | ·4997 | 74 | 74 | ·0543 | 145·7195. | 6 | 585·7195. | ·9457 | 74 |
| 283·3824 | ·5072 | 75 | 73 | ·0470 | 159·7738 | 7 | 539·7738 | ·9530 | 73 |
| 237·8752 | ·5147 | 75 | 75 | ·0395 | 173·8208 | 8 | 493·8208 | ·9605 | 75 |
| 192·3605 | ·5221 | 74 | 73 | ·0322 | 187·8603 | 9 | 447·8603 | ·9678 | 73 |
| 146·8384 | ·5296 | 75 | 74 | ·0248 | 201·8925 | 10 | 401·8925 | ·9752 | 74 |
| 101·3088 | ·5371 | 75 | 74 | ·0174 | 215·9173 | 1 | 355·9173 | ·9826 | 74 |
| 055·7717 | ·5445 | 74 | 74 | ·0100 | 229·9347 | 2 | 309·9347 | ·9900 | 74 |
| 32010·2272 | ·5520 | 75 | 73 | 14·0027 | 243·9447 | 3 | 263·9447 | ·9973 | 73 |
| 31964·6752 | ·5595 | 75 | 75 | 13·9952 | 257·9474 | 4 | 217·9474 | 46·0048 | 75 |
| 919·1157 | ·5669 | 74 | 73 | ·9879 | 271·9426 | 15 | 171·9426 | ·0121 | 73 |
| 873·5488 | ·5744 | 75 | 74 | ·9805 | 285·9305 | 6 | 125·9305 | ·0195 | 74 |
| 827·9744 | ·5819 | 75 | 74 | ·9731 | 299·9110 | 7 | 079·9110 | ·0269 | 74 |
| 782·3925 | ·5893 | 74 | 73 | ·9658 | 313·8841 | 8 | 29033·8841 | ·0342 | 73 |
| 736·8032 | ·5967 | 74 | 75 | ·9583 | 327·8499 | 9 | 28987·8499 | ·0417 | 75 |
| 691·2065. | ·6042 | 75 | 73 | ·9510 | 341·8082 | 20 | 941·8082 | ·0490 | 73 |
| 645·6023 | ·6117 | 75 | 74 | ·9436 | 355·7592 | 1 | 895·7592 | ·0564 | 74 |
| 599·9906 | ·6191 | 74 | 73 | ·9363 | 369·7028 | 2 | 849·7028 | ·0637 | 73 |
| 554·3715. | ·6266 | 75 | 74 | ·9289 | 383·6391 | 3 | 803·6391 | ·0711 | 74 |
| 508·7449 | ·6340 | 74 | 74 | ·9215 | 397·5680 | 4 | 757·5680 | ·0785 | 74 |
| 463·1109 | ·6415 | 75 | 74 | ·9141 | 411·4895. | 25 | 711·4895. | ·0859 | 74 |
| 417·4694 | ·6489 | 74 | 73 | ·9068 | 425·4036 | 6 | 665·4036 | ·0932 | 73 |
| 371·8205 | ·6563 | 74 | 74 | ·8994 | 439·3104 | 7 | 619·3104 | ·1006 | 74 |
| 326·1642 | ·6638 | 75 | 73 | ·8921 | 453·2098 | 8 | 573·2098 | ·1079 | 73 |
| 280·5004 | ·6712 | 74 | 74 | ·8847 | 467·1019 | 9 | 527·1019 | ·1153 | 74 |
| 234·8292 | ·6787 | 75 | 74 | ·8773 | 480·9866 | 30 | 480·9866 | ·1227 | 74 |
| 189·1505. | ·6861 | 74 | 73 | ·8700 | 494·8639 | 1 | 434·8639 | ·1300 | 73 |
| 143·4644 | ·6936 | 75 | 74 | ·8626 | 508·7339 | 2 | 388·7339 | ·1374 | 74 |
| 097·7708 | ·7010 | 74 | 73 | ·8553 | 522·5965 | 3 | 342·5965 | ·1447 | 73 |
| 052·0698 | ·7084 | 74 | 74 | ·8479 | 536·4518 | 4 | 296·4518 | ·1521 | 74 |
| 31006·3614 | ·7159 | 75 | 74 | ·8405 | 550·2997 | 35 | 250·2997 | ·1595 | 74 |
| 30960·6455 | ·7233 | 74 | 73 | ·8332 | 564·1402 | 6 | 204·1402 | ·1668 | 73 |
| 914·9222 | ·7307 | 74 | 73 | ·8259 | 577·9734 | 7 | 157·9734 | ·1741 | 73 |
| 869·1915. | ·7382 | 75 | 74 | ·8185 | 591·7993 | 8 | 111·7993 | ·1815 | 74 |
| 823·4533 | ·7455 | 73 | 74 | ·8111 | 605·6178 | 9 | 065·6178 | ·1889 | 74 |
| 777·7078 | ·7531 | 76 | 73 | ·8038 | 619·4289 | 40 | 28019·4289 | ·1962 | 73 |
| 731·9547 | ·7604 | 73 | 73 | ·7965 | 633·2327 | 1 | 27973·2327 | ·2035 | 73 |
| 686·1943 | ·7679 | 75 | 74 | ·7891 | 647·0292 | 2 | 927·0292 | ·2109 | 74 |
| 640·4264 | ·7752 | 73 | 73 | ·7818 | 660·8183 | 3 | 880·8183 | ·2182 | 73 |
| 594·6512 | ·7827 | 75 | 74 | ·7744 | 674·6001 | 4 | 834·6001 | ·2256 | 74 |
| 548·8685. | ·7902 | 75 | 73 | ·7671 | 688·3745 | 45 | 788·3745 | ·2329 | 73 |
| 503·0783 | ·7975 | 73 | 73 | ·7598 | 702·1416 | 6 | 742·1416 | ·2402 | 73 |
| 457·2808 | ·8050 | 75 | 74 | ·7524 | 715·9014 | 7 | 695·9014 | ·2476 | 74 |
| 411·4758 | ·8124 | 74 | 73 | ·7451 | 729·6538 | 8 | 649·6538 | ·2549 | 73 |
| 365·6634 | ·8197 | 73 | 74 | ·7377 | 743·3989 | 9 | 603·3989 | ·2623 | 74 |
| 319·8437 | ·8273 | 76 | 73 | ·7304 | 757·1366 | 50 | 557·1366 | ·2696 | 73 |
| 274·0164 | ·8346 | 73 | 73 | ·7231 | 770·8670 | 1 | 510·8670 | ·2769 | 73 |
| 228·1818 | ·8420 | 74 | 73 | ·7158 | 784·5901 | 2 | 464·5901 | ·2842 | 73 |
| 182·3398 | ·8495 | 75 | 74 | ·7084 | 798·3059 | 3 | 418·3059 | ·2916 | 74 |
| 136·4903 | ·8568 | 73 | 73 | ·7011 | 812·0143 | 4 | 372·0143 | ·2989 | 73 |
| 090·6335. | ·8643 | 75 | 73 | ·6938 | 825·7154 | 55 | 325·7154 | ·3062 | 73 |
| 30044·7692 | ·8717 | 74 | 73 | ·6865 | 839·4092 | 6 | 279·4092 | ·3135 | 73 |
| 29998·8975 | ·8790 | 73 | 74 | ·6791 | 853·0957 | 7 | 233·0957 | ·3209 | 74 |
| 953·0185. | ·8865 | 75 | 73 | ·6718 | 866·7748 | 8 | 186·7748 | ·3282 | 73 |
| 907·1320 | | | 73 | | 880·4466 | 9 | 140·4466 | | 73 |
| 29861·2381 | 45·8939 | 74 | | 13·6645 | 145894·1111 | 60 | 27094·1111 | 46·3355 | |

3 A

| Δ°. | Diff. | 33°. | ′ | −33°. | Diff. | Δ°. | Δ°. | Diff. | 34°. |
|---|---|---|---|---|---|---|---|---|---|
| | ″ | ″ | | ″ | ″ | | | ″ | ″ |
| 73 | 13·6572 | 145894·1111 | 0 | 27094·1111 | 46·3428 | 73 | 72 | 13·2206 | 146700·6371 |
| 74 | ·6498 | 907·7683 | 1 | 047·7683 | ·3502 | 74 | 72 | ·2134 | 713·8577 |
| 72 | ·6426 | 921·4181 | 2 | 27001·4181 | ·3574 | 72 | 73 | ·2061 | 727·0711 |
| 74 | ·6352 | 935·0607 | 3 | 26955·0607 | ·3648 | 74 | 72 | ·1989 | 740·2772 |
| 73 | ·6279 | 948·6959 | 4 | 908·6959 | ·3721 | 73 | 72 | ·1917 | 753·4761 |
| 73 | ·6206 | 962·3238 | 5 | 862·3238 | ·3794 | 73 | 73 | ·1844 | 766·6678 |
| 73 | ·6133 | 975·9444 | 6 | 815·9444 | ·3867 | 73 | 71 | ·1773 | 779·8522 |
| 74 | ·6059 | 145989·5577 | 7 | 769·5577 | ·3941 | 74 | 73 | ·1700 | 793·0295 |
| 72 | ·5987 | 146003·1636 | 8 | 723·1636 | ·4013 | 72 | 73 | ·1627 | 806·1995 |
| 73 | ·5914 | 016·7623 | 9 | 676·7623 | ·4086 | 73 | 71 | ·1556 | 819·3622 |
| 74 | ·5840 | 030·3537 | 10 | 630·3537 | ·4160 | 74 | 73 | ·1483 | 832·5178 |
| 72 | ·5768 | 043·9377 | 1 | 583·9377 | ·4232 | 72 | 72 | ·1411 | 845·6661 |
| 73 | ·5695 | 057·5145 | 2 | 537·5145 | ·4305 | 73 | 72 | ·1339 | 858·8072 |
| 74 | ·5621 | 071·0840 | 3 | 491·0840 | ·4379 | 74 | 72 | ·1267 | 871·9411 |
| 72 | ·5549 | 084·6461 | 4 | 444·6461 | ·4451 | 72 | 73 | ·1194 | 885·0678 |
| 74 | ·5475 | 098·2010 | 15 | 398·2010 | ·4525 | 74 | 71 | ·1123 | 898·1872 |
| 72 | ·5403 | 111·7485 | 6 | 351·7485 | ·4597 | 72 | 73 | ·1050 | 911·2995 |
| 74 | ·5329 | 125·2888 | 7 | 305·2888 | ·4671 | 74 | 72 | ·0978 | 924·4045 |
| 72 | ·5257 | 138·8217 | 8 | 258·8217 | ·4743 | 72 | 72 | ·0906 | 937·5023 |
| 73 | ·5184 | 152·3474 | 9 | 212·3474 | ·4816 | 73 | 72 | ·0834 | 950·5929 |
| 73 | ·5111 | 165·8658 | 20 | 165·8658 | ·4889 | 73 | 72 | ·0762 | 963·6763 |
| 73 | ·5038 | 179·3769 | 1 | 119·3769 | ·4962 | 73 | 72 | ·0690 | 976·7525 |
| 73 | ·4965 | 192·8807 | 2 | 072·8807 | ·5035 | 73 | 72 | ·0618 | 146989·8215 |
| 73 | ·4892 | 206·3772 | 3 | 26026·3772 | ·5108 | 73 | 72 | ·0546 | 147002·8833 |
| 73 | ·4819 | 219·8664 | 4 | 25979·8664 | ·5181 | 73 | 72 | ·0474 | 015·9379 |
| 72 | ·4747 | 233·3483 | 25 | 933·3483 | ·5253 | 72 | 72 | ·0402 | 028·9853 |
| 74 | ·4673 | 246·8230 | 6 | 886·8230 | ·5327 | 74 | 72 | ·0330 | 042·0255 |
| 72 | ·4601 | 260·2903 | 7 | 840·2903 | ·5399 | 72 | 72 | ·0258 | 055·0585 |
| 73 | ·4528 | 273·7504 | 8 | 793·7504 | ·5472 | 73 | 72 | ·0186 | 068·0843 |
| 72 | ·4456 | 287·2032 | 9 | 747·2032 | ·5544 | 72 | 72 | ·0114 | 081·1029 |
| 74 | ·4382 | 300·6488 | 30 | 700·6488 | ·5618 | 74 | 72 | 13·0042 | 094·1143 |
| 72 | ·4310 | 314·0870 | 1 | 654·0870 | ·5690 | 72 | 71 | 12·9971 | 107·1185 |
| 73 | ·4237 | 327·5180 | 2 | 607·5180 | ·5763 | 73 | 73 | ·9898 | 120·1156 |
| 73 | ·4164 | 340·9417 | 3 | 560·9417 | ·5836 | 73 | 72 | ·9826 | 133·1054 |
| 72 | ·4092 | 354·3581 | 4 | 514·3581 | ·5908 | 72 | 71 | ·9755 | 146·0880 |
| 73 | ·4019 | 367·7673 | 35 | 467·7673 | ·5981 | 73 | 72 | ·9683 | 159·0635 |
| 73 | ·3946 | 381·1692 | 6 | 421·1692 | ·6054 | 73 | 72 | ·9611 | 172·0318 |
| 73 | ·3873 | 394·5638 | 7 | 374·5638 | 6127 | 73 | 72 | ·9539 | 184·9929 |
| 72 | ·3801 | 407·9511 | 8 | 327·9511 | ·6199 | 72 | 72 | ·9467 | 197·9468 |
| 73 | ·3728 | 421·3312 | 9 | 281·3312 | ·6272 | 73 | 71 | ·9396 | 210·8935 |
| 72 | ·3656 | 434·7040 | 40 | 234·7040 | ·6344 | 72 | 72 | ·9324 | 223·8331 |
| 73 | ·3583 | 448·0696 | 1 | 188·0696 | ·6417 | 73 | 72 | ·9252 | 236·7655 |
| 73 | ·3510 | 461·4279 | 2 | 141·4279 | ·6490 | 73 | 72 | ·9180 | 249·6907 |
| 72 | ·3438 | 474·7789 | 3 | 094·7789 | ·6562 | 72 | 72 | ·9108 | 262·6087 |
| 73 | ·3365 | 488·1227 | 4 | 048·1227 | ·6635 | 73 | 71 | ·9037 | 275·5195 |
| 72 | ·3293 | 501·4592 | 45 | 25001·4592 | ·6707 | 72 | 72 | ·8965 | 288·4232 |
| 73 | ·3220 | 514·7885 | 6 | 24954·7885 | ·6780 | 73 | 71 | ·8894 | 301·3197 |
| 72 | ·3148 | 528·1105 | 7 | 908·1105 | ·6852 | 72 | 72 | ·8822 | 314·2091 |
| 73 | ·3075 | 541·4253 | 8 | 861·4253 | ·6925 | 73 | 72 | ·8750 | 327·0913 |
| 73 | ·3002 | 554·7328 | 9 | 814·7328 | ·6998 | 73 | 72 | ·8678 | 339·9663 |
| 72 | ·2930 | 568·0330 | 50 | 768·0330 | ·7070 | 72 | 71 | ·8607 | 352·8341 |
| 72 | ·2858 | 581·3260 | 1 | 721·3260 | ·7142 | 72 | 72 | ·8535 | 365·6948 |
| 73 | ·2785 | 594·6118 | 2 | 674·6118 | ·7215 | 73 | 71 | ·8464 | 378·5483 |
| 72 | ·2713 | 607·8903 | 3 | 627·8903 | ·7287 | 72 | 72 | ·8392 | 391·3947 |
| 73 | ·2640 | 621·1616 | 4 | 581·1616 | ·7360 | 73 | 72 | ·8320 | 404·2339 |
| 72 | ·2568 | 634·4256 | 55 | 534·4256 | ·7432 | 72 | 71 | ·8249 | 417·0659 |
| 73 | ·2495 | 647·6824 | 6 | 487·6824 | ·7505 | 73 | 72 | ·8177 | 429·8908 |
| 72 | ·2423 | 660·9319 | 7 | 440·9319 | ·7577 | 72 | 72 | ·8105 | 442·7085 |
| 72 | ·2351 | 674·1742 | 8 | 394·1742 | ·7649 | 72 | 70 | ·8035 | 455·5190 |
| 73 | 13·2278 | 687·4093 | 9 | 347·4093 | 46·7722 | 73 | 72 | 12·7963 | 468·3225 |
| | | 146700·6371 | 60 | 24300·6371 | | | | | 147481·1188 |

| ′ | −34°. | Diff. | Δ². | Δ². | Diff. | 35°. | ′ | −35°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|---|
| | ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 0 | 24300·6371 | | 72 | 71 | 12·7892 | 147481·1188 | 0 | 21481·1188 | | 71 |
| | | 46·7794 | | | | | | | 47·2108 | |
| 1 | 253·8577 | ·7866 | 72 | 72 | ·7820 | 493·9080 | 1 | 433·9080 | ·2180 | 72 |
| 2 | 207·0711 | | 73 | 72 | ·7748 | 506·6900 | 2 | 386·6900 | ·2252 | 72 |
| | | ·7939 | | | | | | | ·2323 | |
| 3 | 160·2772 | ·8011 | 72 | 71 | ·7677 | 519·4648 | 3 | 339·4648 | ·2394 | 71 |
| 4 | 113·4761 | ·8083 | 72 | 71 | ·7606 | 532·2325 | 4 | 292·2325 | ·2466 | 71 |
| 5 | 066·6678 | | 73 | 72 | | 544·9931 | 5 | 244·9931 | | 72 |
| | | ·8156 | | | ·7534 | | | | ·2537 | |
| 6 | 24019·8522 | ·8227 | 71 | 71 | ·7463 | 557·7465. | 6 | 197·7465. | ·2609 | 71 |
| 7 | 23973·0295. | ·8300 | 73 | 72 | ·7391 | 570·4928 | 7 | 150·4928 | ·2680 | 72 |
| 8 | 926·1995. | ·8373 | 73 | 71 | ·7320 | 583·2319 | 8 | 103·2319 | ·2751 | 71 |
| 9 | 879·3622 | ·8444 | 71 | 71 | ·7249 | 595·9639 | 9 | 055·9639 | | 71 |
| 10 | 832·5178 | | 73 | 72 | | 608·6888 | 10 | 21008·6888 | | 72 |
| | | ·8517 | | | ·7177 | | | | ·2823 | |
| 1 | 785·6661 | ·8589 | 72 | 71 | ·7106 | 621·4065. | 1 | 20961·4065. | ·2894 | 71 |
| 2 | 738·8072 | ·8661 | 72 | 72 | ·7034 | 634·1171 | 2 | 914·1171 | ·2966 | 72 |
| 3 | 691·9411 | ·8733 | 72 | 70 | ·6964 | 646·8205 | 3 | 866·8205 | ·3036 | 70 |
| 4 | 645·0678 | ·8806 | 73 | 72 | ·6892 | 659·5169 | 4 | 819·5169 | ·3108 | 72 |
| 15 | 598·1872 | ·8877 | 71 | 72 | ·6820 | 672·2061 | 15 | 772·2061 | ·3180 | 72 |
| 6 | 551·2995. | ·8950 | 73 | 70 | ·6750 | 684·8881 | 6 | 724·8881 | ·3250 | 70 |
| 7 | 504·4045 | ·9022 | 72 | 72 | ·6678 | 697·5631 | 7 | 677·5631 | ·3322 | 72 |
| 8 | 457·5023 | ·9094 | 72 | 71 | ·6607 | 710·2309 | 8 | 630·2309 | ·3393 | 71 |
| 9 | 410·5929 | ·9166 | 72 | 71 | ·6536 | 722·8916 | 9 | 582·8916 | ·3464 | 71 |
| 20 | 363·6763 | | 72 | 71 | | 735·5452 | 20 | 535·5452 | | 71 |
| | | ·9238 | | | ·6465 | | | | ·3535 | |
| 1 | 316·7525 | ·9310 | 72 | 71 | ·6394 | 748·1917 | 1 | 488·1917 | ·3606 | 71 |
| 2 | 269·8215 | ·9382 | 72 | 72 | ·6322 | 760·8311 | 2 | 440·8311 | ·3678 | 72 |
| 3 | 222·8833 | ·9454 | 72 | 71 | ·6251 | 773·4633 | 3 | 393·4633 | ·3749 | 71 |
| 4 | 175·9379 | ·9526 | 72 | 71 | ·6180 | 786·0884 | 4 | 346·0884 | ·3820 | 71 |
| 25 | 128·9853 | ·9598 | 72 | 71 | ·6109 | 798·7064 | 25 | 298·7064 | ·3891 | 71 |
| 6 | 082·0255 | ·9670 | 72 | 71 | ·6038 | 811·3173 | 6 | 251·3173 | ·3962 | 71 |
| 7 | 23035·0585. | ·9742 | 72 | 71 | ·5967 | 823·9211 | 7 | 203·9211 | ·4033 | 72 |
| 8 | 22988·0843 | ·9814 | 72 | 72 | ·5895 | 836·5178 | 8 | 156·5178 | ·4105 | 72 |
| 9 | 941·1029 | ·9886 | 72 | 70 | ·5825 | 849·1073 | 9 | 109·1073 | ·4175 | 70 |
| 30 | 894·1143 | | 72 | 71 | | 861·6898 | 30 | 061·6898 | | 71 |
| | | 46·9958 | | | ·5754 | | | | ·4246 | |
| 1 | 847·1185 | 47·0029 | 71 | 72 | ·5682 | 874·2652 | 1 | 20014·2652 | ·4318 | 72 |
| 2 | 800·1156 | ·0102 | 73 | 70 | ·5612 | 886·8334 | 2 | 19966·8334 | ·4388 | 70 |
| 3 | 753·1054 | ·0174 | 72 | 72 | ·5540 | 899·3946 | 3 | 919·3946 | ·4460 | 72 |
| 4 | 706·0880 | ·0245 | 71 | 70 | ·5470 | 911·9486 | 4 | 871·9486 | ·4530 | 70 |
| 35 | 659·0635 | ·0317 | 72 | 71 | ·5399 | 924·4956 | 35 | 824·4956 | ·4601 | 71 |
| 6 | 612·0318 | ·0389 | 72 | 72 | ·5327 | 937·0355. | 6 | 777·0355. | ·4673 | 72 |
| 7 | 564·9929 | ·0461 | 72 | 70 | ·5257 | 949·5682 | 7 | 729·5682 | ·4743 | 70 |
| 8 | 517·9468 | ·0533 | 72 | 71 | ·5186 | 962·0939 | 8 | 682·0939 | ·4814 | 71 |
| 9 | 470·8935 | ·0604 | 71 | 72 | ·5114 | 974·6125 | 9 | 634·6125 | ·4886 | 72 |
| 40 | 423·8331 | | 72 | 70 | | 987·1239 | 40 | 587·1239 | | 70 |
| | | ·0676 | | | ·5044 | | | | ·4956 | |
| 1 | 376·7655. | ·0748 | 72 | 70 | ·4974 | 147999·6283 | 1 | 539·6283 | ·5026 | 70 |
| 2 | 329·6907 | ·0820 | 72 | 72 | ·4902 | 148012·1257 | 2 | 492·1257 | ·5098 | 72 |
| 3 | 282·6087 | ·0892 | 72 | 70 | ·4832 | 024·6159 | 3 | 444·6159 | ·5168 | 70 |
| 4 | 235·5195 | ·0963 | 71 | 72 | ·4760 | 037·0991 | 4 | 397·0991 | ·5240 | 72 |
| 45 | 188·4232 | ·1035 | 72 | 71 | ·4689 | 049·5751 | 45 | 349·5751 | ·5311 | 71 |
| 6 | 141·3197 | ·1106 | 71 | 70 | ·4619 | 062·0440 | 6 | 302·0440 | ·5381 | 70 |
| 7 | 094·2091 | ·1178 | 72 | 71 | ·4548 | 074·5059 | 7 | 254·5059 | ·5452 | 71 |
| 8 | 22047·0913 | ·1250 | 72 | 70 | ·4478 | 086·9607 | 8 | 206·9607 | ·5522 | 70 |
| 9 | 21999·9663 | ·1322 | 72 | 72 | ·4406 | 099·4085. | 9 | 159·4085. | ·5594 | 72 |
| 50 | 952·8341 | | 71 | 70 | | 111·8491 | 50 | 111·8491 | | 70 |
| | | ·1393 | | | ·4336 | | | | ·5664 | |
| 1 | 905·6948 | ·1465 | 72 | 71 | ·4265 | 124·2827 | 1 | 064·2827 | ·5735 | 71 |
| 2 | 858·5483 | ·1536 | 71 | 71 | ·4194 | 136·7092 | 2 | 19016·7092 | ·5806 | 71 |
| 3 | 811·3947 | ·1608 | 72 | 70 | ·4124 | 149·1286 | 3 | 18969·1286 | ·5876 | 70 |
| 4 | 764·2339 | ·1680 | 72 | 71 | ·4053 | 161·5410 | 4 | 921·5410 | ·5947 | 71 |
| 55 | 717·0659 | ·1751 | 71 | 71 | ·3982 | 173·9463 | 55 | 873·9463 | ·6018 | 71 |
| 6 | 669·8908 | ·1823 | 72 | 70 | ·3912 | 186·3445 | 6 | 826·3445 | ·6088 | 70 |
| 7 | 622·7085 | ·1895 | 72 | 71 | ·3841 | 198·7357 | 7 | 778·7357 | ·6159 | 71 |
| 8 | 575·5190 | ·1965 | 70 | 71 | ·3770 | 211·1198 | 8 | 731·1198 | ·6230 | 71 |
| 9 | 528·3225 | | 72 | 70 | | 223·4968 | 9 | 683·4968 | | 70 |
| 60 | 21181·1188 | 47·2037 | | | 12·3700 | 148235·8668 | 60 | 18635·8668 | 47·6300 | |

| | | | | |
|---|---|---|---|---|
| | [illegible] | [illegible] | 2 | [illegible] |
| 70 | ·2783 | 396·0345 | 3 | 18[illegible] |
| 71 | ·2713 | 408·3058 | 4 | 175 |
| 70 | ·2642 | 420·5700 | 15 | 5 |
| 70 | ·2572 | 432·8272 | 6 | 8 |
| 71 | ·2502 | 445·0774 | 7 | 8 |
| 70 | ·2431 | 457·3205. | 8 | 7 |
| 71 | ·2361 | 469·5566 | 9 | 7: |
| | ·2290 | | | |
| 69 | ·2221 | 481·7856 | 20 | 6[illegible] |
| 71 | ·2150 | 494·0077 | 1 | 6: |
| 71 | ·2079 | 506·2227 | 2 | 5[illegible] |
| 69 | ·2010 | 518·4306 | 3 | 53 |
| 71 | ·1939 | 530·6316 | 4 | 49 |
| 70 | ·1869 | 542·8255. | 25 | 44 |
| 70 | ·1799 | 555·0124 | 6 | 39. |
| 71 | ·1728 | 567·1923 | 7 | 34[illegible] |
| 69 | ·1659 | 579·3651 | 8 | 295 |
| 71 | ·1588 | 591·5310 | 9 | 251 |
| 70 | ·1518 | 603·6898 | 30 | 203 |
| 70 | ·1448 | 615·8416 | 1 | 155 |
| 70 | ·1378 | 627·9864 | 2 | 107 |
| 70 | ·1308 | 640·1242 | 3 | 060 |
| 71 | ·1237 | 652·2550. | 4 | 17012· |
| 69 | ·1168 | 664·3787 | 35 | 16964· |
| 71 | ·1097 | 676·4955. | 6 | 916· |
| 69 | ·1028 | 688·6052 | 7 | 868· |
| 71 | ·0957 | 700·7080 | 8 | 820· |
| 69 | ·0888 | 712·8037 | 9 | 772· |
| 71 | ·0817 | 724·8925. | 40 | 724· |
| 69 | ·0748 | 736·9742 | 1 | 676· |
| 71 | ·0677 | 749·0490 | 2 | 629· |
| 69 | ·0608 | 761·1167 | 3 | 581· |
| 71 | ·0537 | 773·1775. | 4 | 533· |
| 69 | ·0468 | 785·2312 | 45 | 485· |
| 70 | ·0398 | 797·2780 | 6 | 437· |
| 71 | ·0327 | 809·3178 | 7 | 389· |
| 69 | ·0258 | 821·3505 | 8 | 341· |
| 70 | ·0188 | 833·3763 | 9 | 293· |
| 60 | | | | |



37 38



| −37°. | Diff. | Δ². | Δ². | Diff. | 38°. | ′ | −38°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 15765·1994 | 48·0580 | 71 | 69 | 11·5267 | 149669·4427 | 0 | 12869·4427 | 48·4733 | 69 |
| 717·1414 | ·0649 | 69 | 68 | ·5199 | 680·9694 | 1 | 820·9694 | ·4801 | 68 |
| 669·0765 | ·0718 | 69 | 70 | ·5129 | 692·4893 | 2 | 772·4893 | ·4871 | 70 |
| 621·0047 | ·0789 | 71 | 68 | ·5061 | 704·0022 | 3 | 724·0022 | ·4939 | 68 |
| 572·9258 | ·0858 | 69 | 68 | ·4993 | 715·5083 | 4 | 675·5083 | ·5007 | 68 |
| 524·8400 | ·0927 | 69 | 70 | ·4923 | 727·0076 | 5 | 627·0076 | ·5077 | 70 |
| 476·7473 | ·0997 | 70 | 68 | ·4855 | 738·4999 | 6 | 578·4999 | ·5145 | 68 |
| 428·6476 | ·1067 | 70 | 69 | ·4786 | 749·9854 | 7 | 529·9854 | ·5214 | 69 |
| 380·5409 | ·1137 | 70 | 68 | ·4718 | 761·4640 | 8 | 481·4640 | ·5282 | 68 |
| 332·4272 | ·1206 | 69 | 69 | ·4649 | 772·9358 | 9 | 432·9358 | ·5351 | 69 |
| 284·3066 | ·1275 | 69 | 69 | ·4580 | 784·4007 | 10 | 384·4007 | ·5420 | 69 |
| 236·1791 | ·1345 | 70 | 68 | ·4512 | 795·8587 | 1 | 335·8587 | ·5488 | 68 |
| 188·0446 | ·1415 | 70 | 69 | ·4443 | 807·3099 | 2 | 287·3099 | ·5557 | 69 |
| 139·9031 | ·1484 | 69 | 68 | ·4375 | 818·7542 | 3 | 238·7542 | ·5625 | 68 |
| 091·7547 | ·1553 | 69 | 69 | ·4306 | 830·1917 | 4 | 190·1917 | ·5694 | 69 |
| 15043·5994 | ·1623 | 70 | 68 | ·4238 | 841·6223 | 15 | 141·6223 | ·5762 | 68 |
| 14995·4371 | ·1692 | 69 | 69 | ·4169 | 853·0461 | 6 | 093·0461 | ·5831 | 69 |
| 947·2679 | ·1762 | 70 | 69 | ·4100 | 864·4630 | 7 | 12044·4630 | ·5900 | 69 |
| 899·0917 | ·1831 | 69 | 68 | ·4032 | 875·8730 | 8 | 11995·8730 | ·5968 | 68 |
| 850·9086 | ·1901 | 70 | 68 | ·3964 | 887·2762 | 9 | 947·2762 | ·6036 | 68 |
| 802·7185 | ·1970 | 69 | 69 | ·3895 | 898·6726 | 20 | 898·6726 | ·6105 | 69 |
| 754·5215 | ·2039 | 69 | 68 | ·3827 | 910·0621 | 1 | 850·0621 | ·6173 | 68 |
| 706·3176 | ·2109 | 70 | 69 | ·3758 | 921·4448 | 2 | 801·4448 | ·6242 | 69 |
| 658·1067 | ·2178 | 69 | 68 | ·3690 | 932·8206 | 3 | 752·8206 | ·6310 | 68 |
| 609·8889 | ·2248 | 70 | 69 | ·3621 | 944·1896 | 4 | 704·1896 | ·6379 | 69 |
| 561·6641 | ·2316 | 68 | 68 | ·3553 | 955·5517 | 25 | 655·5517 | ·6447 | 68 |
| 513·4325· | ·2386 | 70 | 68 | ·3485 | 966·9070 | 6 | 606·9070 | ·6515 | 68 |
| 465·1939 | ·2456 | 70 | 69 | ·3416 | 978·2555· | 7 | 558·2555· | ·6584 | 69 |
| 416·9483 | ·2524 | 68 | 68 | ·3348 | 149989·5971 | 8 | 509·5971 | ·6652 | 68 |
| 368·6959 | ·2594 | 70 | 68 | ·3280 | 150000·9319 | 9 | 460·9319 | ·6720 | 68 |
| 320·4365 | ·2663 | 69 | 68 | ·3212 | 012·2599 | 30 | 412·2599 | ·6788 | 68 |
| 272·1702 | ·2732 | 69 | 69 | ·3143 | 023·5811 | 1 | 363·5811 | ·6857 | 69 |
| 223·8970 | ·2802 | 70 | 68 | ·3075 | 034·8954 | 2 | 314·8954 | ·6925 | 68 |
| 175·6168 | ·2870 | 68 | 69 | ·3006 | 046·2029 | 3 | 266·2029 | ·6994 | 69 |
| 127·3298 | ·2940 | 70 | 67 | ·2939 | 057·5035 | 4 | 217·5035 | ·7061 | 67 |
| 079·0358 | ·3009 | 69 | 69 | ·2870 | 068·7974 | 35 | 168·7974 | ·7130 | 69 |
| 14030·7349 | ·3078 | 69 | 68 | ·2802 | 080·0844 | 6 | 120·0844 | ·7198 | 68 |
| 13982·4271 | ·3147 | 69 | 68 | ·2734 | 091·3646 | 7 | 071·3646 | ·7266 | 68 |
| 934·1124 | ·3217 | 70 | 69 | ·2665 | 102·6380 | 8 | 11022·6380 | ·7335 | 69 |
| 885·7907 | ·3285 | 68 | 67 | ·2598 | 113·9045 | 9 | 10973·9045 | ·7402 | 67 |
| 837·4622 | ·3355 | 70 | 68 | ·2530 | 125·1643 | 40 | 925·1643 | ·7470 | 68 |
| 789·1267 | ·3423 | 68 | 69 | ·2461 | 136·4173 | 1 | 876·4173 | ·7539 | 69 |
| 740·7844 | ·3493 | 70 | 68 | ·2393 | 147·6634 | 2 | 827·6634 | ·7607 | 68 |
| 692·4351 | ·3562 | 69 | 68 | ·2325 | 158·9027 | 3 | 778·9027 | ·7675 | 68 |
| 644·0789 | ·3630 | 68 | 68 | ·2257 | 170·1352 | 4 | 730·1352 | ·7743 | 68 |
| 595·7159 | ·3700 | 70 | 68 | ·2189 | 181·3609 | 45 | 681·3609 | ·7811 | 68 |
| 547·3459 | ·3769 | 69 | 68 | ·2121 | 192·5798 | 6 | 632·5798 | ·7879 | 68 |
| 498·9690 | ·3837 | 68 | 68 | ·2053 | 203·7919 | 7 | 583·7919 | ·7947 | 68 |
| 450·5853 | ·3907 | 70 | 69 | ·1985 | 214·9972 | 8 | 534·9972 | ·8015 | 69 |
| 402·1946 | ·3976 | 69 | 69 | ·1916 | 226·1957 | 9 | 486·1957 | ·8084 | |
| 353·7970 | ·4044 | 68 | 67 | ·1849 | 237·3873 | 50 | 437·3873 | ·8151 | 67 |
| 305·3926 | ·4113 | 69 | 68 | ·1781 | 248·5722 | 1 | 388·5722 | ·8219 | 68 |
| 256·9813 | ·4182 | 69 | 68 | ·1713 | 259·7503 | 2 | 339·7503 | ·8287 | 68 |
| 208·5631 | ·4252 | 70 | 68 | ·1645 | 270·9216 | 3 | 290·9216 | ·8355 | 68 |
| 160·1379 | ·4320 | 68 | 68 | ·1577 | 282·0861 | 4 | 242·0861 | ·8423 | 68 |
| 111·7059 | ·4388 | 68 | 67 | ·1510 | 293·2438 | 55 | 193·2438 | ·8490 | 67 |
| 063·2671 | ·4458 | 70 | 69 | ·1441 | 304·3948 | 6 | 144·3948 | ·8559 | 69 |
| 13014·8213 | ·4527 | 69 | 68 | ·1373 | 315·5389 | 7 | 095·5389 | ·8627 | 68 |
| 12966·3686 | ·4595 | 68 | 67 | ·1306 | 326·6762 | 8 | 10046·6762 | ·8694 | 67 |
| 917·9091 | 48·4664 | 69 | 68 | 11·1238 | 337·8068 | 9 | 9997·8068 | 48·8762 | 68 |
| 12869·4427 | | | | | 150348·9306 | 60 | 9948·9306 | | |

| | | −39°. | Diff. | Δ². | Δ². | Diff. | φ'. |
|---|---|---|---|---|---|---|---|
| | | " | " | | | " | |
| 396 | 0 | 9946·9306 | 48·8830 | 68 | 67 | 10·7130 | 151004·9013 |
| 476 | 1 | 900·0476 | ·8898 | 68 | 66 | ·7064 | 014·7173 |
| 578 | 2 | 851·1578 | ·8966 | 68 | 68 | ·6996 | 025·4237 |
| 612 | 3 | 802·2612 | ·9033 | 67 | 66 | ·6930 | 036·1233 |
| 579 | 4 | 753·3579 | ·9101 | 68 | 66 | ·6864 | 046·8163 |
| 478 | 5 | 704·4478 | ·9169 | 68 | 68 | ·6796 | 057·5027 |
| 309 | 6 | 655·5309 | ·9237 | 68 | 67 | ·6729 | 068·1823 |
| 072 | 7 | 606·6072 | ·9304 | 67 | 66 | ·6663 | 078·8552 |
| 768 | 8 | 557·6768 | ·9372 | 68 | 67 | ·6596 | 089·5215 |
| 396 | 9 | 508·7396 | ·9440 | 68 | 67 | ·6529 | 100·1811 |
| 956 | 10 | 459·7956 | ·9507 | 67 | 66 | ·6463 | 110·8340 |
| 449 | 1 | 410·8449 | ·9575 | 68 | 67 | ·6396 | 121·4803 |
| 874 | 2 | 361·8874 | ·9643 | 68 | 66 | ·6330 | 132·1199 |
| 231 | 3 | 312·9231 | ·9710 | 67 | 67 | ·6263 | 142·7529 |
| 521 | 4 | 263·9521 | ·9778 | 68 | 67 | ·6196 | 153·3792 |
| 743 | 15 | 214·9743 | ·9845 | 67 | 67 | ·6129 | 163·9988 |
| 898 | 6 | 165·9898 | ·9913 | 68 | 66 | ·6063 | 174·6117 |
| 985 | 7 | 116·9985 | 48·9980 | 67 | 67 | ·5996 | 185·2180 |
| 005. | 8 | 068·0005. | 49·0048 | 68 | 66 | ·5930 | 195·8176 |
| 957 | 9 | 9018·9957 | ·0116 | 68 | 67 | ·5863 | 206·4106 |
| 841 | 20 | 8969·9841 | ·0183 | 67 | 66 | ·5797 | 216·9969 |
| 658 | 1 | 920·9658 | ·0250 | 67 | 67 | ·5730 | 227·5766 |
| 408 | 2 | 871·9408 | ·0318 | 68 | 66 | ·5664 | 238·1496 |
| 090 | 3 | 822·9090 | ·0386 | 68 | 67 | ·5597 | 248·7160 |
| 704 | 4 | 773·8704 | ·0453 | 67 | 66 | ·5531 | 259·2757 |
| 251 | 25 | 724·8251 | ·0520 | 67 | 67 | ·5464 | 269·8288 |
| 731 | 6 | 675·7731 | ·0588 | 68 | 66 | ·5398 | 280·3752 |
| 143 | 7 | 626·7143 | ·0655 | 67 | 66 | ·5332 | 290·9150 |
| 488 | 8 | 577·6488 | ·0722 | 67 | 67 | ·5265 | 301·4482 |
| 766 | 9 | 528·5766 | ·0790 | 68 | 66 | ·5199 | 311·9747 |
| 976 | 30 | 479·4976 | ·0857 | 67 | 67 | ·5132 | 322·4946 |
| 119 | 1 | 430·4119 | ·0925 | 68 | 66 | ·5066 | 333·0078 |
| 194 | 2 | 381·3194 | ·0991 | 66 | 66 | ·5000 | 343·5144 |



41



| | −40°. | Diff. | Δ². | Δ². | Diff. | 41°. | ′ | −42°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|---|
| | ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 0 | 7004·0043 | 49·2870 | 67 | 66 | 10·3149 | 151635·0127 | 0 | 4035·0127 | 49·6851 | 66 |
| 1 | 6954·7173 | ·2936 | 66 | 66 | ·3083 | 645·3276 | 1 | 3985·3276 | ·6917 | 66 |
| 2 | 905·4237 | ·3004 | 68 | 65 | ·3018 | 655·6359 | 2 | 935·6359 | ·6982 | 65 |
| 3 | 856·1233 | ·3070 | 66 | 66 | ·2952 | 665·9377 | 3 | 885·9377 | ·7048 | 66 |
| 4 | 806·8163 | ·3136 | 66 | 66 | ·2886 | 676·2329 | 4 | 836·2329 | ·7114 | 66 |
| 5 | 757·5027 | ·3204 | 68 | 66 | ·2820 | 686·5215 | 5 | 786·5215 | ·7180 | 66 |
| 6 | 708·1823 | ·3271 | 67 | 65 | ·2755 | 696·8035 | 6 | 736·8035 | ·7245 | 65 |
| 7 | 658·8552 | ·3337 | 66 | 66 | ·2689 | 707·0790 | 7 | 687·0790 | ·7311 | 66 |
| 8 | 609·5215. | ·3404 | 67 | 66 | ·2623 | 717·3479 | 8 | 637·3479 | ·7377 | 66 |
| 9 | 560·1811 | ·3471 | 67 | 66 | ·2557 | 727·6102 | 9 | 587·6102 | ·7443 | 66 |
| 0 | 510·8340 | ·3537 | 66 | 65 | ·2492 | 737·8659 | 10 | 537·8659 | ·7508 | 65 |
| 1 | 461·4803 | ·3604 | 67 | 66 | ·2426 | 748·1151 | 1 | 488·1151 | ·7574 | 66 |
| 2 | 412·1199 | ·3670 | 66 | 66 | ·2360 | 758·3577 | 2 | 438·3577 | ·7640 | 66 |
| 3 | 362·7529 | ·3737 | 67 | 65 | ·2295 | 768·5937 | 3 | 388·5937 | ·7705 | 65 |
| 4 | 313·3792 | ·3804 | 67 | 66 | ·2229 | 778·8232 | 4 | 338·8232 | ·7771 | 66 |
| 5 | 263·9988 | ·3871 | 67 | 66 | ·2163 | 789·0461 | 15 | 289·0461 | ·7837 | 66 |
| 6 | 214·6117 | ·3937 | 66 | 65 | ·2098 | 799·2624 | 6 | 239·2624 | ·7902 | 65 |
| 7 | 165·2180 | ·4004 | 67 | 65 | ·2033 | 809·4722 | 7 | 189·4722 | ·7967 | 65 |
| 8 | 115·8176 | ·4070 | 66 | 66 | ·1967 | 819·6755. | 8 | 139·6755. | ·8033 | 66 |
| 9 | 066·4106 | ·4137 | 67 | 66 | ·1901 | 829·8722 | 9 | 089·8722 | ·8099 | 66 |
| 0 | 6016·9969 | ·4203 | 66 | 66 | ·1835 | 840·0623 | 20 | 3040·0623 | ·8165 | 66 |
| 1 | 5967·5766 | ·4270 | 67 | 65 | ·1770 | 850·2458 | 1 | 2990·2458 | ·8230 | 65 |
| 2 | 918·1496 | ·4336 | 66 | 65 | ·1705 | 860·4228 | 2 | 940·4228 | ·8295 | 65 |
| 3 | 868·7160 | ·4403 | 67 | 66 | ·1639 | 870 5933 | 3 | 890·5933 | ·8361 | 66 |
| 4 | 819·2757 | ·4469 | 66 | 65 | ·1574 | 880·7572 | 4 | 840·7572 | ·8426 | 65 |
| 5 | 769·8288 | ·4536 | 67 | 66 | ·1508 | 890·9146 | 25 | 790·9146 | ·8492 | 66 |
| 6 | 720·3752 | ·4602 | 66 | 65 | ·1443 | 901·0654 | 6 | 741·0654 | ·8557 | 65 |
| 7 | 670·9150 | ·4668 | 66 | 66 | ·1377 | 911·2097 | 7 | 691·2097 | ·8623 | 66 |
| 8 | 621·4482 | ·4735 | 67 | 65 | ·1312 | 921·3474 | 8 | 641·3474 | ·8688 | 65 |
| 9 | 571·9747 | ·4801 | 66 | 65 | ·1247 | 931·4786 | 9 | 591·4786 | ·8753 | 65 |
| | 522·4946 | ·4868 | 67 | 65 | ·1182 | 941·6033 | 30 | 541·6033 | ·8818 | 65 |
| | 473·0078 | ·4934 | 66 | 66 | ·1116 | 951·7215. | 1 | 491·7215. | ·8884 | 66 |
| | 423·5144 | ·5000 | 66 | 66 | ·1050 | 961·8331 | 2 | 441·8331 | ·8950 | 66 |
| | 374·0144 | ·5066 | 66 | 65 | ·0985 | 971·9381 | 3 | 391·9381 | ·9015 | 65 |
| | 324·5078 | ·5133 | 67 | 65 | ·0920 | 982·0366 | 4 | 342·0366 | ·9080 | 65 |
| | 274·9945. | ·5199 | 66 | 65 | ·0855 | 151992·1286 | 35 | 292·1286 | ·9145 | 65 |
| | 225·4746 | ·5266 | 67 | 65 | ·0790 | 152002·2141 | 6 | 242·2141 | ·9210 | 65 |
| | 175·9480 | ·5332 | 66 | 66 | ·0724 | 012·2931 | 7 | 192·2931 | ·9276 | 66 |
| | 126·4148 | ·5397 | 65 | 65 | ·0659 | 022·3655 | 8 | 142·3655 | ·9341 | 65 |
| | 076·8751 | ·5464 | 67 | 65 | ·0594 | 032·4314 | 9 | 092·4314 | ·9406 | 65 |
| | 5027·3287 | ·5531 | 67 | 65 | ·0529 | 042·4908 | 40 | 2042·4908 | ·9471 | 65 |
| | 4977·7756 | ·5596 | 65 | 66 | ·0463 | 052·5437 | 1 | 1992·5437 | ·9537 | 66 |
| | 928·2160 | ·5663 | 67 | 65 | ·0398 | 062·5900 | 2 | 942·5900 | ·9602 | 65 |
| | 878·6497 | ·5729 | 66 | 65 | ·0333 | 072·6298 | 3 | 892·6298 | ·9667 | 65 |
| | 829·0768 | ·5794 | 65 | 65 | ·0268 | 082·6631 | 4 | 842·6631 | ·9732 | 65 |
| | 779·4974 | ·5861 | 67 | 65 | ·0203 | 092·6899 | 45 | 792·6899 | ·9797 | 65 |
| | 729·9113 | ·5928 | 67 | 65 | ·0138 | 102·7102 | 6 | 742·7102 | ·9862 | 65 |
| | 680·3185 | ·5993 | 65 | 65 | ·0073 | 112·7240 | 7 | 692·7240 | ·9927 | 65 |
| | 630·7192 | ·6059 | 66 | 65 | 10·0008 | 122·7313 | 8 | 642·7313 | 49·9992 | 65 |
| | 581·1133 | ·6125 | 66 | | 9·9943 | 132·7321 | 9 | 592·7321 | 50·0057 | |
| | 531·5008 | ·6191 | 66 | 66 | ·9877 | 142·7264 | 50 | 542·7264 | ·0123 | 66 |
| | 481·8817 | ·6258 | 67 | 64 | ·9813 | 152·7141 | 1 | 492·7141 | ·0187 | 64 |
| | 432·2559 | ·6323 | 65 | 65 | ·9748 | 162·6954 | 2 | 442·6954 | ·0252 | 65 |
| | 382·6236 | ·6389 | 66 | 66 | ·9682 | 172·6702 | 3 | 392·6702 | ·0318 | 66 |
| | 332·9847 | ·6456 | 67 | 64 | ·9618 | 182·6384 | 4 | 342·6384 | ·0382 | 64 |
| | 283·3391 | ·6521 | 65 | 65 | ·9553 | 192·6002 | 55 | 292·6002 | ·0447 | 65 |
| | 233·6870 | ·6587 | 66 | 65 | ·9488 | 202·5555. | 6 | 242·5555. | ·0512 | 65 |
| | 184·0283 | ·6653 | 66 | 65 | ·9423 | 212·5043 | 7 | 192·5043 | ·0577 | 65 |
| | 134·3630 | ·6718 | 65 | 65 | ·9358 | 222·4466 | 8 | 142·4466 | ·0642 | 65 |
| | 084·6912 | ·6785 | 67 | 65 | 9·9293 | 232·3824 | 9 | 092·3824 | 50·0707 | |
| | 4035·0127 | 49·6785 | | | | 152242·3117 | 60 | 1042·3117 | | |

| | ′ | −39°.′ | Diff. | Δ′. | Δ′. | Diff. | 40°. |
|---|---|---|---|---|---|---|---|
| | | ″ | ″ | | | ″ | ″ |
| 906 | 0 | 9946·9306 | 48·8830 | 68 | 67 | 10·7130 | 151004·004 |
| 776 | 1 | 900·0476 | ·8898 | 68 | 66 | ·7064 | 014·717 |
| 678 | 2 | 851·1578 | ·8966 | 68 | 68 | ·6996 | 025·423 |
| 112 | 3 | 802·2612 | ·9033 | 67 | 66 | ·6930 | 036·123 |
| 579 | 4 | 753·3579 | ·9101 | 68 | 66 | ·6864 | 046·816 |
| 478 | 5 | 704·4478 | ·9169 | 68 | 68 | ·6796 | 057·502 |
| 309 | 6 | 655·5309 | ·9237 | 68 | 67 | ·6729 | 068·182 |
| 072 | 7 | 606·6072 | ·9304 | 67 | 66 | ·6663 | 078·855 |
| 768 | 8 | 557·6768 | ·9372 | 68 | 67 | ·6596 | 089·521 |
| 396 | 9 | 508·7396 | ·9440 | 68 | 67 | ·6529 | 100·181 |
| 956 | 10 | 459·7956 | ·9507 | 67 | 66 | ·6463 | 110·834 |
| 449 | 1 | 410·8449 | ·9575 | 68 | 67 | ·6396 | 121·480 |
| 874 | 2 | 361·8874 | ·9643 | 68 | 66 | ·6330 | 132·119 |
| 231 | 3 | 312·9231 | ·9710 | 67 | 67 | ·6263 | 142·752 |
| 521 | 4 | 263·9521 | ·9778 | 68 | 67 | ·6196 | 153·379 |
| 743 | 15 | 214·9743 | ·9845 | 67 | 67 | ·6129 | 163·998 |
| 898 | 6 | 165·9898 | ·9913 | 68 | 66 | ·6063 | 174·611 |
| 985 | 7 | 116·9985 | 48·9980 | 67 | 67 | ·5996 | 185·218 |
| 005. | 8 | 068·0005. | 49·0048 | 68 | 66 | ·5930 | 195·817 |
| 957 | 9 | 9018·9957 | ·0116 | 68 | 67 | ·5863 | 206·410 |
| 841 | 20 | 8969·9841 | ·0183 | 67 | 66 | ·5797 | 216·996 |
| 658 | 1 | 920·9658 | ·0250 | 67 | 67 | ·5730 | 227·576 |
| 406 | 2 | 871·9408 | ·0318 | 68 | 66 | ·5664 | 238·149 |
| 090 | 3 | 822·9090 | ·0386 | 68 | 67 | ·5597 | 248·716 |
| 704 | 4 | 773·8704 | ·0453 | 67 | 66 | ·5531 | 259·275 |
| 251 | 25 | 724·8251 | ·0520 | 67 | 67 | ·5464 | 269·828 |
| 731 | 6 | 675·7731 | ·0588 | 68 | 66 | ·5398 | 280·375 |
| 143 | 7 | 626·7143 | ·0655 | 67 | 66 | ·5332 | 290·915 |
| 488 | 8 | 577·6488 | ·0722 | 67 | 67 | ·5265 | 301·448 |
| 766 | 9 | 528·5766 | ·0790 | 68 | 66 | ·5199 | 311·974 |
| 976 | 30 | 479·4976 | ·0857 | 67 | 67 | ·5132 | 322·494 |
| 119 | 1 | 430·4119 | | 68 | 66 | | 333·007 |

| | −40°. | Diff. | Δ². | Δ². | Diff. | 41°. | | −π°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|---|
| | ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 0 | 7004·0043 | | 67 | 66 | | 151635·0127 | 0 | 4035·0127 | | 66 |
| | | 49·2870 | | | 10·3149 | | | | 49·6851 | |
| 1 | 6954·7173 | | 66 | 66 | | 645·3276 | 1 | 3985·3276 | | 66 |
| | | ·2936 | | | ·3083 | | | | ·6917 | |
| 2 | 905·4237 | | 68 | 65 | | 655·6359 | 2 | 935·6359 | | 65 |
| | | ·3004 | | | ·3018 | | | | ·6982 | |
| 3 | 856·1233 | | 66 | 66 | | 665·9377 | 3 | 885·9377 | | 66 |
| | | ·3070 | | | ·2952 | | | | ·7048 | |
| 4 | 806·8163 | | 66 | 66 | | 676·2329 | 4 | 836·2329 | | 66 |
| | | ·3136 | | | ·2886 | | | | ·7114 | |
| 5 | 757·5027 | | 68 | 66 | | 686·5215 | 5 | 786·5215 | | 66 |
| | | ·3204 | | | ·2820 | | | | ·7180 | |
| 6 | 708·1823 | | 67 | 65 | | 696·8035 | 6 | 736·8035 | | 65 |
| | | ·3271 | | | ·2755 | | | | ·7245 | |
| 7 | 658·8552 | | 66 | 66 | | 707·0790 | 7 | 687·0790 | | 66 |
| | | ·3337 | | | ·2689 | | | | ·7311 | |
| 8 | 609·5215· | | 67 | 66 | | 717·3479 | 8 | 637·3479 | | 66 |
| | | ·3404 | | | ·2623 | | | | ·7377 | |
| 9 | 560·1811 | | 67 | 66 | | 727·6102 | 9 | 587·6102 | | 66 |
| | | ·3471 | | | ·2557 | | | | ·7443 | |
| 10 | 510·8340 | | 66 | 65 | | 737·8659 | 10 | 537·8659 | | 65 |
| | | ·3537 | | | ·2492 | | | | ·7508 | |
| 1 | 461·4803 | | 67 | 66 | | 748·1151 | 1 | 488·1151 | | 66 |
| | | ·3604 | | | ·2426 | | | | ·7574 | |
| 2 | 412·1199 | | 66 | 66 | | 758·3577 | 2 | 438·3577 | | 66 |
| | | ·3670 | | | ·2360 | | | | ·7640 | |
| 3 | 362·7529 | | 67 | 65 | | 768·5937 | 3 | 388·5937 | | 65 |
| | | ·3737 | | | ·2295 | | | | ·7705 | |
| 4 | 313·3792 | | 67 | 66 | | 778·8232 | 4 | 338·8232 | | 66 |
| | | ·3804 | | | ·2229 | | | | ·7771 | |
| 15 | 263·9988 | | 67 | 66 | | 789·0461 | 15 | 289·0461 | | 66 |
| | | ·3871 | | | ·2163 | | | | ·7837 | |
| 6 | 214·6117 | | 66 | 65 | | 799·2624 | 6 | 239·2624 | | 65 |
| | | ·3937 | | | ·2098 | | | | ·7902 | |
| 7 | 165·2180 | | 67 | 65 | | 809·4722 | 7 | 189·4722 | | 65 |
| | | ·4004 | | | ·2033 | | | | ·7967 | |
| 8 | 115·8176 | | 66 | 66 | | 819·6755· | 8 | 139·6755· | | 66 |
| | | ·4070 | | | ·1967 | | | | ·8033 | |
| 9 | 066·4106 | | 67 | 66 | | 829·8722 | 9 | 089·8722 | | 66 |
| | | ·4137 | | | ·1901 | | | | ·8099 | |
| 20 | 6016·9969 | | 66 | 66 | | 840·0623 | 20 | 3040·0623 | | 66 |
| | | ·4203 | | | ·1835 | | | | ·8165 | |
| 1 | 5967·5766 | | 67 | 65 | | 850·2458 | 1 | 2990·2458 | | 65 |
| | | ·4270 | | | ·1770 | | | | ·8230 | |
| 2 | 918·1496 | | 66 | 65 | | 860·4228 | 2 | 940·4228 | | 65 |
| | | ·4336 | | | ·1705 | | | | ·8295 | |
| 3· | 868·7160 | | 67 | 66 | | 870 5933 | 3 | 890·5933 | | 66 |
| | | ·4403 | | | ·1639 | | | | ·8361 | |
| 4 | 819·2757 | | 66 | 65 | | 880·7572 | 4 | 840·7572 | | 65 |
| | | ·4469 | | | ·1574 | | | | ·8426 | |
| 25 | 769·8288 | | 67 | 66 | | 890·9146 | 25 | 790·9146 | | 66 |
| | | ·4536 | | | ·1508 | | | | ·8492 | |
| 6 | 720·3752 | | 66 | 65 | | 901·0654 | 6 | 741·0654 | | 65 |
| | | ·4602 | | | ·1443 | | | | ·8557 | |
| 7 | 670·9150 | | 66 | 66 | | 911·2097 | 7 | 691·2097 | | 66 |
| | | ·4668 | | | ·1377 | | | | ·8623 | |
| 8 | 621·4482 | | 67 | 65 | | 921·3474 | 8 | 641·3474 | | 65 |
| | | ·4735 | | | ·1312 | | | | ·8688 | |
| 9 | 571·9747 | | 66 | 65 | | 931·4786 | 9 | 591·4786 | | 65 |
| | | ·4801 | | | ·1247 | | | | ·8753 | |
| 30 | 522·4946 | | 67 | 65 | | 941·6033 | 30 | 541·6033 | | 65 |
| | | ·4868 | | | ·1182 | | | | ·8818 | |
| 1 | 473·0078 | | 66 | 66 | | 951·7215· | 1 | 491·7215· | | 66 |
| | | ·4934 | | | ·1116 | | | | ·8884 | |
| 2 | 423·5144 | | 66 | 66 | | 961·8331 | 2 | 441·8331 | | 66 |
| | | ·5000 | | | ·1050 | | | | ·8950 | |
| 3 | 374·0144 | | 66 | 65 | | 971·9381 | 3 | 391·9381 | | 65 |
| | | ·5066 | | | ·0985 | | | | ·9015 | |
| 4 | 324·5078 | | 67 | 65 | | 982·0366 | 4 | 342·0366 | | 65 |
| | | ·5133 | | | ·0920 | | | | ·9080 | |
| 35 | 274·9945· | | 66 | 65 | | 151992·1286 | 35 | 292·1286 | | 65 |
| | | ·5199 | | | ·0855 | | | | ·9145 | |
| 6 | 225·4746 | | 67 | 65 | | 152002·2141 | 6 | 242·2141 | | 65 |
| | | ·5266 | | | ·0790 | | | | ·9210 | |
| 7 | 175·9480 | | 66 | 66 | | 012·2931 | 7 | 192·2931 | | 66 |
| | | ·5332 | | | ·0724 | | | | ·9276 | |
| 8 | 126·4148 | | 65 | 65 | | 022·3655 | 8 | 142·3655 | | 65 |
| | | ·5397 | | | ·0659 | | | | ·9341 | |
| 9 | 076·8751 | | 67 | 65 | | 032·4314 | 9 | 092·4314 | | 65 |
| | | ·5464 | | | ·0594 | | | | ·9406 | |
| 40 | 5027·3287 | | 67 | 65 | | 042·4908 | 40 | 2042·4908 | | 65 |
| | | ·5531 | | | ·0529 | | | | ·9471 | |
| 1 | 4977·7756 | | 65 | 66 | | 052·5437 | 1 | 1992·5437 | | 66 |
| | | ·5596 | | | ·0463 | | | | ·9537 | |
| 2 | 928·2160 | | 67 | 65 | | 062·5900 | 2 | 942·5900 | | 65 |
| | | ·5663 | | | ·0398 | | | | ·9602 | |
| 3 | 878·6497 | | 66 | 65 | | 072·6298 | 3 | 892·6298 | | 65 |
| | | ·5729 | | | ·0333 | | | | ·9667 | |
| 4 | 829·0768 | | 65 | 65 | | 082·6631 | 4 | 842·6631 | | 65 |
| | | ·5794 | | | ·0268 | | | | ·9732 | |
| 45 | 779·4974 | | 67 | 65 | | 092·6899 | 45 | 792·6899 | | 65 |
| | | ·5861 | | | ·0203 | | | | ·9797 | |
| 6 | 729·9113 | | 67 | 65 | | 102·7102 | 6 | 742·7102 | | 65 |
| | | ·5928 | | | ·0138 | | | | ·9862 | |
| 7 | 680·3185 | | 65 | 65 | | 112·7240 | 7 | 692·7240 | | 65 |
| | | ·5993 | | | ·0073 | | | | ·9927 | |
| 8 | 630·7192 | | 66 | 65 | | 122·7313 | 8 | 642·7313 | | 65 |
| | | ·6059 | | | 10·0008 | | | | 49·9992 | |
| 9 | 581·1133 | | 66 | 65 | | 132·7321 | 9 | 592·7321 | | 65 |
| | | ·6125 | | | 9·9943 | | | | 50·0057 | |
| 50 | 531·5008 | | 66 | 66 | | 142·7264 | 50 | 542·7264 | | 66 |
| | | ·6191 | | | ·9877 | | | | ·0123 | |
| 1 | 481·8817 | | 67 | 64 | | 152·7141 | 1 | 492·7141 | | 64 |
| | | ·6258 | | | ·9813 | | | | ·0187 | |
| 2 | 432·2559 | | 65 | 65 | | 162·6954 | 2 | 442·6954 | | 65 |
| | | ·6323 | | | ·9748 | | | | ·0252 | |
| 3 | 382·6236 | | 66 | 66 | | 172·6702 | 3 | 392·6702 | | 66 |
| | | ·6389 | | | ·9682 | | | | ·0318 | |
| 4 | 332·9847 | | 67 | 64 | | 182·6384 | 4 | 342·6384 | | 64 |
| | | ·6456 | | | ·9618 | | | | ·0382 | |
| 55 | 283·3391 | | 65 | 65 | | 192·6002 | 55 | 292·6002 | | 65 |
| | | ·6521 | | | ·9553 | | | | ·0447 | |
| 6 | 233·6870 | | 66 | 65 | | 202·5555· | 6 | 242·5555· | | 65 |
| | | ·6587 | | | ·9488 | | | | ·0512 | |
| 7 | 184·0283 | | 66 | 65 | | 212·5043 | 7 | 192·5043 | | 65 |
| | | ·6653 | | | ·9423 | | | | ·0577 | |
| 8 | 134·3630 | | 65 | 65 | | 222·4466 | 8 | 142·4466 | | 65 |
| | | ·6718 | | | ·9358 | | | | ·0642 | |
| 9 | 084·6912 | | 67 | 65 | | 232·3824 | 9 | 092·3824 | | 65 |
| | | | | | 9·9293 | | | | 50·0707 | |
| 60 | 4035·0127 | 49·6785 | | | | 152242·3117 | 60 | 1042·3117 | | |

| | | −40°. | Dif. | 4′ | 5′ | Dif. | 42°+ |
|---|---|---|---|---|---|---|---|
| | | ° | ″ | | | ″ | ° |
| 17 | 0 | 1042·3117 | 59·0771 | 64 | 65 | 59·5368 | 1528·26·26·43 |
| 46 | 1 | 982·2346 | ·0837 | 66 | 63 | ·5305 | 835·8011 |
| 29 | 2 | 942·1509 | ·0901 | 64 | 64 | ·5241 | 845·3321 |
| 38 | 3 | 892·0608 | ·0966 | 65 | 64 | ·5177 | 854·8630 |
| 42 | 4 | 841·9642 | ·1031 | 65 | 63 | ·5114 | 864·3939 |
| 11 | 5 | 791·8611 | ·1096 | 65 | 64 | ·5050 | 873·8851 |
| 15 | 6 | 741·7515 | ·1160 | 64 | 64 | ·4986 | 883·3901 |
| 55 | 7 | 691·6355 | ·1225 | 65 | 64 | ·4922 | 892·8864 |
| 30 | 8 | 641·5130 | ·1290 | 65 | 63 | ·4859 | 902·3811 |
| 40 | 9 | 591·3840 | ·1354 | 64 | 64 | ·4795 | 911·8670 |
| 86 | 10 | 541·2486 | ·1420 | 66 | 64 | ·4731 | 921·3463 |
| 66 | 1 | 491·1066 | ·1483 | 63 | 63 | ·4668 | 930·8196 |
| 83 | 2 | 440·9583 | ·1549 | 66 | 64 | ·4604 | 940·2864 |
| 34 | 3 | 390·8034 | ·1613 | 64 | 64 | ·4540 | 949·7466 |
| 21 | 4 | 340·6421 | ·1678 | 65 | 63 | ·4477 | 959·2002 |
| 43 | 15 | 290·4743 | ·1742 | 64 | 64 | ·4413 | 968·6484 |
| 21 | 6 | 240·3001 | ·1807 | 65 | 63 | ·4350 | 978·0898 |
| 94 | 7 | 190·1194 | ·1872 | 65 | 64 | ·4286 | 987·5247 |
| 22 | 8 | 139·9322 | ·1936 | 64 | 63 | ·4223 | 1529·96·9534 |
| 86 | 9 | 89·7386 | ·2000 | 64 | 64 | ·4159 | 1530·06·3757 |
| 86 | 20 | 39·5386 | ·2065 | 65 | 63 | ·4096 | 015·7916 |
| 21 | 1 | 10·6679 | ·2130 | 65 | 64 | ·4032 | 025·2012 |
| 91 | 2 | 60·8809 | ·2194 | 64 | 63 | ·3969 | 034·6044 |
| 97 | 3 | 111·1003 | ·2258 | 64 | 63 | ·3906 | 044·0013 |
| 39 | 4 | 161·3261 | ·2323 | 65 | 64 | ·3842 | 053·3919 |
| 16 | 25 | 211·5584 | ·2387 | 64 | 64 | ·3778 | 062·7761 |
| 29 | 6 | 261·7971 | ·2452 | 65 | 62 | ·3716 | 072·1539 |
| 77 | 7 | 312·0423 | ·2516 | 64 | 64 | ·3652 | 081·5255 |
| 61 | 8 | 362·2939 | ·2581 | 65 | 64 | ·3588 | 090·8907 |
| 80 | 9 | 412·5520 | ·2645 | 64 | 63 | ·3525 | 100·2495 |
| 35 | 30 | 462·8165 | ·2709 | 64 | 63 | ·3462 | 109·6020 |
| 26 | 1 | 513·0874 | ·2774 | 65 | 63 | ·3399 | 118·9482 |
| 52 | 2 | 563·3648 | ·2838 | 64 | 64 | ·3335 | 128·2881 |

| ′ | −40°. | Diff. | Δ². | Δ². | Diff. | 41°. | ′ | −41°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|---|
| | ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 0 | 7004·0043 | 49·2870 | 67 | 66 | 10·3149 | 151635·0127 | 0 | 4035·0127 | 49·6851 | 66 |
| 1 | 6954·7173 | ·2936 | 66 | 66 | ·3083 | 645·3276 | 1 | 3985·3276 | ·6917 | 66 |
| 2 | 905·4237 | ·3004 | 68 | 65 | ·3018 | 655·6359 | 2 | 935·6359 | ·6982 | 65 |
| 3 | 856·1233 | ·3070 | 66 | 66 | ·2952 | 665·9377 | 3 | 885·9377 | ·7048 | 66 |
| 4 | 806·8163 | ·3136 | 66 | 66 | ·2886 | 676·2329 | 4 | 836·2329 | ·7114 | 66 |
| 5 | 757·5027 | ·3204 | 68 | 66 | ·2820 | 686·5215 | 5 | 786·5215 | ·7180 | 66 |
| 6 | 708·1823 | ·3271 | 67 | 65 | ·2755 | 696·8035 | 6 | 736·8035 | ·7245 | 65 |
| 7 | 658·8552 | ·3337 | 66 | 66 | ·2689 | 707·0790 | 7 | 687·0790 | ·7311 | 66 |
| 8 | 609·5215· | ·3404 | 67 | 66 | ·2623 | 717·3479 | 8 | 637·3479 | ·7377 | 66 |
| 9 | 560·1811 | ·3471 | 67 | 66 | ·2557 | 727·6102 | 9 | 587·6102 | ·7443 | 66 |
| 10 | 510·8340 | | 66 | 65 | | 737·8659 | 10 | 537·8659 | | 65 |
| 1 | 461·4803 | ·3537 | 67 | 66 | ·2492 | 748·1151 | 1 | 488·1151 | ·7508 | 66 |
| 2 | 412·1199 | ·3604 | 66 | 66 | ·2426 | 758·3577 | 2 | 438·3577 | ·7574 | 66 |
| 3 | 362·7529 | ·3670 | 67 | 65 | ·2360 | 768·5937 | 3 | 388·5937 | ·7640 | 65 |
| 4 | 313·3792 | ·3737 | 67 | 66 | ·2295 | 778·8232 | 4 | 338·8232 | ·7705 | 66 |
| 15 | 263·9988 | ·3804 | 67 | 66 | ·2229 | 789·0461 | 15 | 289·0461 | ·7771 | 66 |
| 6 | 214·6117 | ·3871 | 66 | 65 | ·2163 | 799·2624 | 6 | 239·2624 | ·7837 | 65 |
| 7 | 165·2180 | ·3937 | 67 | 65 | ·2098 | 809·4722 | 7 | 189·4722 | ·7902 | 65 |
| 8 | 115·8176 | ·4004 | 66 | 66 | ·2033 | 819·6755· | 8 | 139·6755· | ·7967 | 66 |
| 9 | 066·4106 | ·4070 | 67 | 66 | ·1967 | 829·8722 | 9 | 089·8722 | ·8033 | 66 |
| | | ·4137 | | | ·1901 | | | | ·8099 | |
| 20 | 6016·9969 | | 66 | 66 | | 840·0623 | 20 | 3040·0623 | | 66 |
| 1 | 5967·5766 | ·4203 | 67 | 65 | ·1835 | 850·2458 | 1 | 2990·2458 | ·8165 | 65 |
| 2 | 918·1496 | ·4270 | 66 | 65 | ·1770 | 860·4228 | 2 | 940·4228 | ·8230 | 65 |
| 3· | 868·7160 | ·4336 | 67 | 66 | ·1705 | 870 5933 | 3 | 890·5933 | ·8295 | 66 |
| 4 | 819·2757 | ·4403 | 66 | 65 | ·1639 | 880·7572 | 4 | 840·7572 | ·8361 | 65 |
| 25 | 769·8288 | ·4469 | 67 | 66 | ·1574 | 890·9146 | 25 | 790·9146 | ·8426 | 66 |
| 6 | 720·3752 | ·4536 | 66 | 65 | ·1508 | 901·0654 | 6 | 741·0654 | ·8492 | 65 |
| 7 | 670·9150 | ·4602 | 66 | 66 | ·1443 | 911·2097 | 7 | 691·2097 | ·8557 | 66 |
| 8 | 621·4482 | ·4668 | 67 | 65 | ·1377 | 921·3474 | 8 | 641·3474 | ·8623 | 65 |
| 9 | 571·9747 | ·4735 | 66 | 65 | ·1312 | 931·4786 | 9 | 591·4786 | ·8688 | 65 |
| | | ·4801 | | | ·1247 | | | | ·8753 | |
| 30 | 522·4946 | | 67 | 65 | | 941·6033 | 30 | 541·6033 | | 65 |
| 1 | 473·0078 | ·4868 | 66 | 66 | ·1182 | 951·7215· | 1 | 491·7215· | ·8818 | 66 |
| 2 | 423·5144 | ·4934 | 66 | 66 | ·1116 | 961·8331 | 2 | 441·8331 | ·8884 | 66 |
| 3 | 374·0144 | ·5000 | 66 | 65 | ·1050 | 971·9381 | 3 | 391·9381 | ·8950 | 65 |
| 4 | 324·5078 | ·5066 | 67 | 65 | ·0985 | 982·0366 | 4 | 342·0366 | ·9015 | 65 |
| 35 | 274·9945· | ·5133 | 66 | 65 | ·0920 | 151992·1286 | 35 | 292·1286 | ·9080 | 65 |
| 6 | 225·4746 | ·5199 | 67 | 65 | ·0855 | 152002·2141 | 6 | 242·2141 | ·9145 | 65 |
| 7 | 175·9480 | ·5266 | 66 | 66 | ·0790 | 012·2931 | 7 | 192·2931 | ·9210 | 66 |
| 8 | 126·4148 | ·5332 | 65 | 65 | ·0724 | 022·3655 | 8 | 142·3655 | ·9276 | 65 |
| 9 | 076·8751 | ·5397 | 67 | 65 | ·0659 | 032·4314 | 9 | 092·4314 | ·9341 | 65 |
| | | ·5464 | | | ·0594 | | | | ·9406 | |
| 40 | 5027·3287 | | 67 | 65 | | 042·4908 | 40 | 2042·4908 | | 65 |
| 1 | 4977·7756 | ·5531 | 65 | 66 | ·0529 | 052·5437 | 1 | 1992·5437 | ·9471 | 66 |
| 2 | 928·2160 | ·5596 | 67 | 65 | ·0463 | 062·5900 | 2 | 942·5900 | ·9537 | 65 |
| 3 | 878·6497 | ·5663 | 66 | 65 | ·0398 | 072·6298 | 3 | 892·6298 | ·9602 | 65 |
| 4 | 829·0768 | ·5729 | 65 | 65 | ·0333 | 082·6631 | 4 | 842·6631 | ·9667 | 65 |
| 45 | 779·4974 | ·5794 | 67 | 65 | ·0268 | 092·6899 | 45 | 792·6899 | ·9732 | 65 |
| 6 | 729·9113 | ·5861 | 67 | 65 | ·0203 | 102·7102 | 6 | 742·7102 | ·9797 | 65 |
| 7 | 680·3185 | ·5928 | 65 | 65 | ·0138 | 112·7240 | 7 | 692·7240 | ·9862 | 65 |
| 8 | 630·7192 | ·5993 | 66 | 65 | ·0073 | 122·7313 | 8 | 642·7313 | ·9927 | 65 |
| 9 | 581·1133 | ·6059 | 66 | 65 | 10·0008 | 132·7321 | 9 | 592·7321 | 49·9992 | 65 |
| | | ·6125 | | | 9·9943 | | | | 50·0057 | |
| 50 | 531·5008 | | 66 | 66 | | 142·7264 | 50 | 542·7264 | | 66 |
| 1 | 481·8817 | ·6191 | 67 | 64 | ·9877 | 152·7141 | 1 | 492·7141 | ·0123 | 64 |
| 2 | 432·2559 | ·6258 | 65 | 65 | ·9813 | 162·6954 | 2 | 442·6954 | ·0187 | 65 |
| 3 | 382·6236 | ·6323 | 66 | 66 | ·9748 | 172·6702 | 3 | 392·6702 | ·0252 | 66 |
| 4 | 332·9847 | ·6389 | 67 | 64 | ·9682 | 182·6384 | 4 | 342·6384 | ·0318 | 64 |
| 55 | 283·3391 | ·6456 | 65 | 65 | ·9618 | 192·6002 | 55 | 292·6002 | ·0382 | 65 |
| 6 | 233·6870 | ·6521 | 66 | 65 | ·9553 | 202·5555· | 6 | 242·5555· | ·0447 | 65 |
| 7 | 184·0283 | ·6587 | 66 | 65 | ·9488 | 212·5043 | 7 | 192·5043 | ·0512 | 65 |
| 8 | 134·3630 | ·6653 | 65 | 65 | ·9423 | 222·4466 | 8 | 142·4466 | ·0577 | 65 |
| 9 | 084·6912 | ·6718 | 67 | 65 | ·9358 | 232·3824 | 9 | 092·3824 | ·0642 | 65 |
| 60 | 4035·0127 | 49·6785 | | | 9·9293 | 152242·3117 | 60 | 1042·3117 | 50·0707 | |

| | | −45°. | Diff. | Δ². | Δ³. | Diff. | 46°. |
|---|---|---|---|---|---|---|---|
| | | ″ | ″ | | | ″ | ″ |
| 16 | 0 | 8074·3784 | | 62 | 60 | 8·4168 | 154441·7871 |
| 53 | 1 | 125·5947 | 51·2163 | 61 | 61 | ·4107 | 450·2039 |
| 29 | 2 | 176·8171 | ·2224 | 63 | 61 | ·4046 | 458·6146 |
| 42 | 3 | 228·0458 | ·2287 | 61 | 60 | ·3986 | 467·0192 |
| 94 | 4 | 279·2806 | ·2348 | 61 | 60 | ·3926 | 475·4178 |
| 85 | 5 | 330·5215 | ·2409 | 62 | 61 | ·3865 | 483·8104 |
| 14 | 6 | 381·7686 | ·2471 | 62 | 61 | ·3804 | 492·1969 |
| 81 | 7 | 433·0219 | ·2533 | 61 | 60 | ·3744 | 500·5773 |
| 87 | 8 | 484·2813 | ·2594 | 62 | 60 | ·3684 | 508·9517 |
| 31 | 9 | 535·5469 | ·2656 | 62 | 61 | ·3623 | 517·3201 |
| | | | ·2718 | | | | |
| 13 | 10 | 586·8187 | | 61 | 61 | ·3562 | 525·6824 |
| 34 | 1 | 638·0966 | ·2779 | 61 | 60 | ·3502 | 534·0386 |
| 04 | 2 | 689·3806 | ·2840 | 62 | 60 | ·3442 | 542·3888 |
| 92 | 3 | 740·6708 | ·2902 | 61 | 61 | ·3381 | 550·7330 |
| 29 | 4 | 791·9671 | ·2963 | 62 | 60 | ·3321 | 559·0711 |
| 04 | 15 | 843·2696 | ·3025 | 62 | 60 | ·3261 | 567·4032 |
| 17 | 6 | 894·5783 | ·3087 | 61 | 61 | ·3200 | 575·7293 |
| 89 | 7 | 945·8931 | ·3148 | 61 | 60 | ·3140 | 584·0493 |
| 70 | 8 | 8997·2140 | ·3209 | 61 | 60 | ·3080 | 592·3633 |
| 90 | 9 | 9048·5410 | ·3270 | 62 | 61 | ·3019 | 600·6713 |
| | | | ·3332 | | | | |
| 58 | 20 | 099·8742 | | 61 | 59 | ·2960 | 608·9732 |
| 65 | 1 | 151·2135 | ·3393 | 62 | 61 | ·2899 | 617·2692 |
| 10 | 2 | 202·5590 | ·3455 | 61 | 61 | ·2838 | 625·5591 |
| 04 | 3 | 253·9106 | ·3516 | 61 | 59 | ·2779 | 633·8429 |
| 17 | 4 | 305·2683 | ·3577 | 61 | 61 | ·2718 | 642·1208 |
| 79 | 25 | 356·6321 | ·3638 | 62 | 60 | ·2658 | 650·3926 |
| 79 | 6 | 408·0021 | ·3700 | 61 | 60 | ·2598 | 658·6584 |
| 18 | 7 | 459·3782 | ·3761 | 61 | 60 | ·2538 | 666·9182 |
| 66 | 8 | 510·7604 | ·3822 | 62 | 60 | ·2478 | 675·1720 |
| 12 | 9 | 562·1488 | ·3884 | 60 | 60 | ·2418 | 683·4198 |
| | | | ·3944 | | | | |
| 68 | 30 | 613·5432 | | 62 | 60 | ·2358 | 691·6616 |
| 62 | 1 | 664·9438 | ·4006 | 61 | 61 | ·2297 | 699·8974 |
| 95 | 2 | 716·3505 | ·4067 | 61 | 60 | ·2237 | 708·1271 |
| | | | ·4128 | | | | |



47



| −46°. | Diff. | Δ². | Δ³. | Diff. | 47°. | ′ | −47°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| 11158″2129 | 51·5832 | 60 | 60 | 8·0564 | 154936″1298 | 0 | 14263″8702 | 51·9436 | 60 |
| 209·7961 | ·5893 | 61 | 59 | ·0505 | 944·1862 | 1 | 315·8138 | ·9495 | 59 |
| 261·3854 | ·5954 | 61 | 60 | ·0445 | 952·2367 | 2 | 367·7633 | ·9555 | 60 |
| 312·9808 | ·6014 | 60 | 59 | ·0386 | 960·2812 | 3 | 419·7188 | ·9614 | 59 |
| 364·5822 | ·6074 | 60 | 60 | ·0326 | 968·3198 | 4 | 471·6802 | ·9674 | 60 |
| 416·1896 | ·6135 | 61 | 59 | ·0267 | 976·3524 | 5 | 523·6476 | ·9733 | 59 |
| 467·8031 | ·6196 | 61 | 60 | ·0207 | 984·3791 | 6 | 575·6209 | ·9793 | 60 |
| 519·4227 | ·6256 | 60 | 59 | ·0148 | 154992·3998 | 7 | 627·6002 | ·9852 | 59 |
| 571·0483 | ·6316 | 60 | 59 | ·0089 | 155000·4146 | 8 | 679·5854 | ·9911 | 59 |
| 622·6799 | ·6377 | 61 | 60 | 8·0029 | 008·4235. | 9 | 731·5765 | 51·9971 | 60 |
| 674·3176 | ·6438 | 61 | 59 | 7·9970 | 016·4264 | 10 | 783·5736 | 52·0030 | 59 |
| 725·9614 | ·6498 | 60 | 59 | ·9911 | 024·4234 | 1 | 835·5766 | ·0089 | 59 |
| 777·6112 | ·6558 | 60 | 60 | ·9851 | 032·4145. | 2 | 887·5855 | ·0149 | 60 |
| 829·2670 | ·6619 | 61 | 59 | ·9792 | 040·3996 | 3 | 939·6004 | ·0208 | 59 |
| 880·9289 | ·6679 | 60 | 59 | ·9733 | 048·3788 | 4 | 14991·6212 | ·0267 | 59 |
| 932·5968 | ·6739 | 60 | 59 | ·9674 | 056·3521 | 15 | 15043·6479 | ·0326 | 59 |
| 11984·2707 | ·6800 | 61 | 60 | ·9614 | 064·3195. | 6 | 095·6805 | ·0386 | 60 |
| 12035·9507 | ·6860 | 60 | 59 | ·9555 | 072·2809 | 7 | 147·7191 | ·0445 | 59 |
| 087·6367 | ·6920 | 60 | 59 | ·9496 | 080·2364 | 8 | 199·7636 | ·0504 | 59 |
| 139·3287 | ·6981 | 61 | 59 | ·9437 | 088·1860 | 9 | 251·8140 | ·0563 | 59 |
| 191·0268 | ·7040 | 59 | 59 | ·9378 | 096·1297 | 20 | 303·8703 | ·0622 | 59 |
| 242·7308 | ·7101 | 61 | 59 | ·9319 | 104·0675 | 1 | 355·9325. | ·0681 | 59 |
| 294·4409 | ·7162 | 61 | 60 | ·9259 | 111·9994 | 2 | 408·0006 | ·0741 | 60 |
| 346·1571 | ·7221 | 59 | 58 | ·9201 | 119·9253 | 3 | 460·0747 | ·0799 | 58 |
| 397·8792 | ·7282 | 61 | 60 | ·9141 | 127·8454 | 4 | 512·1546 | ·0859 | 60 |
| 449·6074 | ·7342 | 60 | 59 | ·9082 | 135·7595 | 25 | 564·2405. | ·0918 | 59 |
| 501·3416 | ·7402 | 60 | 58 | ·9024 | 143·6677 | 6 | 616·3323 | ·0976 | 58 |
| 553·0818 | ·7462 | 60 | 60 | ·8964 | 151·5701 | 7 | 668·4299 | ·1036 | 60 |
| 604·8280 | ·7522 | 60 | 59 | ·8905 | 159·4665. | 8 | 720·5335 | ·1095 | 59 |
| 656·5802 | ·7582 | 60 | 59 | ·8846 | 167·3570 | 9 | 772·6430 | ·1154 | 59 |
| 708·3384 | ·7642 | 60 | 59 | ·8787 | 175·2416 | 30 | 824·7584 | ·1213 | 59 |
| 760·1026 | ·7703 | 61 | 58 | ·8729 | 183·1203 | 1 | 876·8797 | ·1271 | 58 |
| 811·8729 | ·7763 | 60 | 59 | ·8670 | 190·9932 | 2 | 929·0068 | ·1330 | 59 |
| 863·6492 | ·7822 | 59 | 60 | ·8610 | 198·8602 | 3 | 15981·1398 | ·1390 | 60 |
| 915·4314 | ·7882 | 60 | 58 | ·8552 | 206·7212 | 4 | 16033·2788 | ·1448 | 58 |
| 12967·2196 | ·7943 | 61 | 59 | ·8493 | 214·5764 | 35 | 085·4236 | ·1507 | 59 |
| 13019·0139 | ·8002 | 59 | 59 | ·8434 | 222·4257 | 6 | 137·5743 | ·1566 | 59 |
| 070·8141 | ·8062 | 60 | 59 | ·8375 | 230·2691 | 7 | 189·7309 | ·1625 | 59 |
| 122·6203 | ·8123 | 61 | 59 | ·8316 | 238·1066 | 8 | 241·8934 | ·1684 | 59 |
| 174·4326 | ·8182 | 59 | 58 | ·8258 | 245·9382 | 9 | 294·0618 | ·1742 | 58 |
| 226·2508 | ·8242 | 60 | 60 | ·8198 | 253·7640 | 40 | 346·2360 | ·1802 | 60 |
| 278·0750. | ·8302 | 60 | 58 | ·8140 | 261·5838 | 1 | 398·4162 | ·1860 | 58 |
| 329·9052 | ·8361 | 59 | 58 | ·8082 | 269·3978 | 2 | 450·6022 | ·1918 | 58 |
| 381·7413 | ·8422 | 61 | 60 | ·8022 | 277·2060 | 3 | 502·7940 | ·1978 | 60 |
| 433·5835 | ·8481 | 59 | 58 | ·7964 | 285·0082 | 4 | 554·9918 | ·2036 | 58 |
| 485·4316 | ·8541 | 60 | 59 | ·7905 | 292·8046 | 45 | 607·1954 | ·2095 | 59 |
| 537·2857 | ·8601 | 60 | 58 | ·7847 | 300·5951 | 6 | 659·4049 | ·2153 | 58 |
| 589·1458 | ·8661 | 60 | 59 | ·7788 | 308·3798 | 7 | 711·6202 | ·2212 | 59 |
| 641·0119 | ·8721 | 60 | 59 | ·7729 | 316·1586 | 8 | 763·8414 | ·2271 | 59 |
| 692·8840 | ·8780 | 59 | 58 | ·7671 | 323·9315 | 9 | 816·0685. | ·2329 | 58 |
| 744·7620 | ·8840 | 60 | 59 | ·7612 | 331·6986 | 50 | 868·3014 | ·2388 | 59 |
| 796·6460 | ·8899 | 59 | 58 | ·7554 | 339·4598 | 1 | 920·5402 | ·2446 | 58 |
| 848·5359 | ·8959 | 60 | 59 | ·7495 | 347·2152 | 2 | 16972·7848 | ·2505 | 59 |
| 900·4318 | ·9019 | 60 | 59 | ·7436 | 354·9647 | 3 | 17025·0353 | ·2564 | 59 |
| 13952·3337 | ·9079 | 60 | 58 | ·7378 | 362·7083 | 4 | 077·2917 | ·2622 | 58 |
| 14004·2416 | ·9138 | 59 | 58 | ·7320 | 370·4461 | 55 | 129·5539 | ·2680 | 58 |
| 056·1554 | ·9198 | 60 | 59 | ·7261 | 378·1781 | 6 | 181·8219 | ·2739 | 59 |
| 108·0752 | ·9257 | 59 | 59 | ·7202 | 385·9042 | 7 | 234·0958 | ·2798 | 59 |
| 160·0009 | ·9317 | 60 | 58 | ·7144 | 393·6244 | 8 | 286·3756 | ·2856 | 58 |
| 211·9326 | 51·9376 | 59 | 58 | 7·7086 | 401·3388 | 9 | 338·6612 | 52·2914 | 58 |
| 14263·8702 | | | | | 155409·0474 | 60 | 17390·9526 | | |

| | ′ | −48°. | Diff. | Δ². | Δ³. | Diff. | 49°. |
|---|---|---|---|---|---|---|---|
| | | ″ | ″ | | | ″ | ″ |
| 4 | 0 | 17390·9526 | 52·2972 | 58 | 56 | 7·3559 | 155860·944 |
| 12 | 1 | 443·2498 | ·3031 | 59 | 58 | ·3501 | 868·300 |
| 1 | 2 | 495·5529 | ·3090 | 59 | 57 | ·3444 | 875·650 |
| 11 | 3 | 547·8619 | ·3147 | 57 | 57 | ·3387 | 882·994 |
| 14 | 4 | 600·1766 | ·3206 | 59 | 57 | ·3330 | 890·333 |
| 8 | 5 | 652·4972 | ·3265 | 59 | 58 | ·3272 | 897·666 |
| 13 | 6 | 704·8237 | ·3323 | 58 | 56 | ·3216 | 904·993 |
| 10 | 7 | 757·1560 | ·3380 | 57 | 58 | ·3158 | 912·315 |
| 10 | 8 | 809·4940 | ·3439 | 59 | 57 | ·3101 | 919·630 |
| 11 | 9 | 861·8379 | ·3498 | 59 | 57 | ·3044 | 926·941 |
| 13 | 10 | 914·1877 | ·3555 | 57 | 57 | ·2987 | 934·245 |
| 8 | 1 | 17966·5432 | ·3614 | 59 | 57 | ·2930 | 941·544 |
| 4 | 2 | 18018·9046 | ·3672 | 58 | 57 | ·2873 | 948·837 |
| 12 | 3 | 071·2718 | ·3730 | 58 | 57 | ·2816 | 956·124 |
| 2 | 4 | 123·6448 | ·3788 | 58 | 57 | ·2759 | 963·406 |
| 4 | 15 | 176·0236 | ·3846 | 58 | 57 | ·2702 | 970·681 |
| 8 | 6 | 228·4082 | ·3905 | 59 | 57 | ·2645 | 977·952 |
| 3 | 7 | 280·7987 | ·3962 | 57 | 57 | ·2588 | 985·216 |
| 1 | 8 | 333·1949 | ·4021 | 59 | 56 | ·2532 | 992·475 |
| 0 | 9 | 385·5970 | ·4078 | 57 | 58 | ·2474 | 155999·728 |
| 2 | 20 | 438·0048 | ·4137 | 59 | 56 | ·2418 | 156006·976 |
| 5 | 1 | 490·4185 | ·4194 | 57 | 58 | ·2360 | 014·217 |
| 1 | 2 | 542·8379 | ·4252 | 58 | 56 | ·2304 | 021·453 |
| 9 | 3 | 595·2631 | ·4311 | 59 | 57 | ·2247 | 028·684 |
| 8 | 4 | 647·6942 | ·4368 | 57 | 57 | ·2190 | 035·908 |
| 0 | 25 | 700·1310 | ·4427 | 59 | 56 | ·2134 | 043·127 |
| 3 | 6 | 752·5737 | ·4484 | 57 | 58 | ·2076 | 050·341 |
| 9 | 7 | 805·0221 | ·4542 | 58 | 56 | ·2020 | 057·548 |
| 7 | 8 | 857·4763 | ·4600 | 58 | 56 | ·1964 | 064·759 |
| 7 | 9 | 909·9363 | ·4658 | 58 | 58 | ·1906 | 071·947 |
| 9 | 30 | 18962·4021 | ·4715 | 57 | 56 | ·1850 | 079·137 |
| 4 | 1 | 19014·8736 | ·4774 | 59 | 57 | ·1793 | 086·322 |
| 0 | 2 | 067·3510 | ·4831 | 57 | 56 | ·1737 | 093·502 |



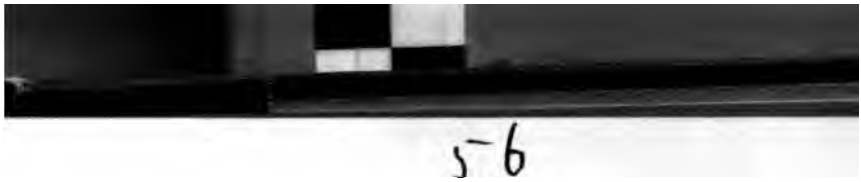


| −49°. | Diff. | Δ². | Δ³. | Diff. | 50°. | ′ | −50°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 20539·0558 | 52·6441 | 56 | 56 | 7·0159 | 156292·2309 | 0 | 23707·7691 | 52·9841 | 56 |
| 591·6999 | ·6499 | 58 | 57 | ·0102 | 299·2468 | 1 | 760·7532 | ·9898 | 57 |
| 644·3498 | ·6556 | 57 | 56 | 7·0046 | 306·2570 | 2 | 813·7430 | 52·9954 | 56 |
| 697·0054 | ·6613 | 57 | 55 | 6·9991 | 313·2616 | 3 | 866·7384 | 53·0009 | 55 |
| 749·6667 | ·6670 | 57 | 57 | ·9934 | 320·2607 | 4 | 919·7393 | ·0066 | 57 |
| 802·3337 | ·6728 | 58 | 55 | ·9879 | 327·2541 | 5 | 23972·7459 | ·0121 | 55 |
| 855·0065 | ·6784 | 56 | 57 | ·9822 | 334·2420 | 6 | 24025·7580 | ·0178 | 57 |
| 907·6849 | ·6842 | 58 | 55 | ·9767 | 341·2242 | 7 | 078·7758 | ·0233 | 55 |
| 20960·3691 | ·6899 | 57 | 57 | ·9710 | 348·2009 | 8 | 131·7991 | ·0290 | 57 |
| 21013·0590 | ·6956 | 57 | 55 | ·9655 | 355·1719 | 9 | 184·8281 | ·0345 | 55 |
| 065·7546 | ·7013 | 57 | 56 | ·9599 | 362·1374 | 10 | 237·8626 | ·0401 | 56 |
| 118·4559 | ·7070 | 57 | 56 | ·9543 | 369·0973 | 1 | 290·9027 | ·0457 | 56 |
| 171·1629 | ·7127 | 57 | 56 | ·9487 | 376·0516 | 2 | 343·9484 | ·0513 | 56 |
| 223·8756 | ·7184 | 57 | 56 | ·9431 | 383·0003 | 3 | 396·9997 | ·0569 | 56 |
| 276·5940 | ·7241 | 57 | 56 | ·9375 | 389·9434 | 4 | 450·0566 | ·0625 | 56 |
| 329·3181 | ·7298 | 57 | 55 | ·9320 | 396·8809 | 15 | 503·1191 | ·0680 | 55 |
| 382·0479 | ·7355 | 57 | 56 | ·9264 | 403·8129 | 6 | 556·1871 | ·0736 | 56 |
| 434·7834 | ·7412 | 57 | 56 | ·9208 | 410·7393 | 7 | 609·2607 | ·0792 | 56 |
| 487·5246 | ·7468 | 56 | 56 | ·9152 | 417·6601 | 8 | 662·3399 | ·0848 | 56 |
| 540·2714 | ·7526 | 58 | 56 | ·9096 | 424·5753 | 9 | 715·4247 | ·0904 | 56 |
| 593·0240 | ·7582 | 56 | 55 | ·9041 | 431·4849 | 20 | 768·5151 | ·0959 | 55 |
| 645·7822 | ·7640 | 58 | 56 | ·8985 | 438·3890 | 1 | 821·6110 | ·1015 | 56 |
| 698·5462 | ·7696 | 56 | 55 | ·8930 | 445·2875 | 2 | 874·7125 | ·1070 | 55 |
| 751·3158 | ·7753 | 57 | 56 | ·8874 | 452·1805 | 3 | 927·8195 | ·1126 | 56 |
| 804·0911 | ·7810 | 57 | 56 | ·8818 | 459·0679 | 4 | 24980·9321 | ·1182 | 56 |
| 856·8721 | ·7866 | 56 | 56 | ·8762 | 465·9497 | 25 | 25034·0503 | ·1238 | 56 |
| 909·6587 | ·7924 | 58 | 55 | ·8707 | 472·8259 | 6 | 087·1741 | ·1293 | 55 |
| 21962·4511 | ·7980 | 56 | 55 | ·8652 | 479·6966 | 7 | 140·3034 | ·1348 | 55 |
| 22015·2491 | ·8036 | 56 | 56 | ·8596 | 486·5618 | 8 | 193·4382 | ·1404 | 56 |
| 068·0527 | ·8094 | 58 | 56 | ·8540 | 493·4214 | 9 | 246·5786 | ·1460 | 56 |
| 120·8621 | ·8150 | 56 | 55 | ·8485 | 500·2754 | 30 | 299·7246 | ·1515 | 55 |
| 173·6771 | ·8207 | 57 | 56 | ·8429 | 507·1239 | 1 | 352·8761 | ·1571 | 56 |
| 226·4978 | ·8263 | 56 | 55 | ·8374 | 513·9668 | 2 | 406·0332 | ·1626 | 55 |
| 279·3241 | ·8320 | 57 | 55 | ·8319 | 520·8042 | 3 | 459·1958 | ·1681 | 55 |
| 332·1561 | ·8377 | 57 | 56 | ·8263 | 527·6361 | 4 | 512·3639 | ·1737 | 56 |
| 384·9938 | ·8433 | 56 | 56 | ·8207 | 534·4624 | 35 | 565·5376 | ·1793 | 56 |
| 437·8371 | ·8490 | 57 | 54 | ·8153 | 541·2831 | 6 | 618·7169 | ·1847 | 54 |
| 490·6861 | ·8546 | 56 | 56 | ·8097 | 548·0984 | 7 | 671·9016 | ·1903 | 56 |
| 543·5407 | ·8603 | 57 | 56 | ·8041 | 554·9081 | 8 | 725·0919 | ·1959 | 56 |
| 596·4010 | ·8659 | 56 | 55 | ·7986 | 561·7122 | 9 | 778·2878 | ·2014 | 55 |
| 649·2669 | ·8716 | 57 | 55 | ·7931 | 568·5108 | 40 | 831·4892 | ·2069 | 55 |
| 702·1385 | ·8772 | 56 | 55 | ·7876 | 575·3039 | 1 | 884·6961 | ·2124 | 55 |
| 755·0157 | ·8829 | 57 | 56 | ·7820 | 582·0915 | 2 | 937·9085 | ·2180 | 56 |
| 807·8986 | ·8885 | 56 | 55 | ·7765 | 588·8735 | 3 | 25991·1265 | ·2235 | 55 |
| 860·7871 | ·8942 | 57 | 55 | ·7710 | 595·6500 | 4 | 26044·3500 | ·2290 | 55 |
| 913·6813 | ·8998 | 56 | 55 | ·7655 | 602·4210 | 45 | 097·5790 | ·2345 | 55 |
| 22966·5811 | ·9054 | 56 | 56 | ·7599 | 609·1865 | 6 | 150·8135 | ·2401 | 56 |
| 23019·4865 | ·9111 | 57 | 55 | ·7544 | 615·9464 | 7 | 204·0536 | ·2456 | 55 |
| 072·3976 | ·9167 | 56 | 55 | ·7489 | 622·7008 | 8 | 257·2992 | ·2511 | 55 |
| 125·3143 | ·9223 | 56 | 55 | ·7434 | 629·4497 | 9 | 310·5503 | ·2566 | 55 |
| 178·2366 | ·9279 | 56 | 55 | ·7379 | 636·1931 | 50 | 363·8069 | ·2621 | 55 |
| 231·1645 | ·9336 | 57 | 55 | ·7324 | 642·9310 | 1 | 417·0690 | ·2676 | 55 |
| 284·0981 | ·9392 | 56 | 55 | ·7269 | 649·6634 | 2 | 470·3366 | ·2731 | 55 |
| 337·0373 | ·9449 | 57 | 56 | ·7213 | 656·3903 | 3 | 523·6097 | ·2787 | 56 |
| 389·9822 | ·9504 | 55 | 54 | ·7159 | 663·1116 | 4 | 576·8884 | ·2841 | 54 |
| 442·9326 | ·9561 | 57 | 56 | ·7103 | 669·8275 | 55 | 630·1725 | ·2897 | 56 |
| 495·8887 | ·9617 | 56 | 54 | ·7049 | 676·5378 | 6 | 683·4622 | ·2951 | 54 |
| 548·8504 | ·9673 | 56 | 56 | ·6993 | 683·2427 | 7 | 736·7573 | ·3007 | 56 |
| 601·8177 | ·9729 | 56 | 54 | ·6939 | 689·9420 | 8 | 790·0580 | ·3061 | 54 |
| 654·7906 | 52·9785 | | 55 | 6·6884 | 696·6359 | 9 | 843·3641 | 53·3116 | 55 |
| 23707·7691 | | | | | 156703·3243 | 60 | 26896·6757 | | |

| | $-51^2$. | Diff. | $\Delta^3$. | $\Delta^2$ | Diff. | $51^2$. |
|---|---|---|---|---|---|---|
| | | " | | | " | " |
| 0 | 26890·6757 | 53·3172 | 56 | 54 | 6·3570 | 157094·647 |
| 1 | 26943·9929 | ·3226 | 54 | 54 | ·3516 | 101·004 |
| 2 | 27003·3155 | ·3281 | 55 | 54 | ·3462 | 107·356 |
| 3 | 056·6436 | ·3336 | 55 | 53 | ·3409 | 113·702 |
| 4 | 109·9772 | ·3391 | 55 | 54 | ·3355 | 120·043 |
| 5 | 163·3163 | ·3445 | 54 | 53 | ·3302 | 126·378 |
| 6 | 216·6608 | ·3500 | 55 | 54 | ·3248 | 132·708 |
| 7 | 270·0108 | ·3556 | 56 | 54 | ·3194 | 139·033 |
| 8 | 323·3664 | ·3610 | 54 | 53 | ·3141 | 145·353 |
| 9 | 376·7274 | ·3664 | 54 | 54 | ·3087 | 151·667 |
| 10 | 430·0938 | ·3719 | 55 | 53 | ·3034 | 157·975 |
| 1 | 483·4657 | ·3774 | 55 | 54 | ·2980 | 164·278 |
| 2 | 536·8431 | ·3829 | 55 | 53 | ·2927 | 170·575 |
| 3 | 590·2260 | ·3883 | 54 | 54 | ·2873 | 176·870 |
| 4 | 643·6143 | ·3938 | 55 | 53 | ·2820 | 183·157 |
| 5 | 697·0081 | ·3993 | 55 | 53 | ·2767 | 189·439 |
| 6 | 750·4074 | ·4047 | 54 | 54 | ·2713 | 195·716 |
| 7 | 803·8121 | ·4102 | 55 | 54 | ·2659 | 201·987 |
| 8 | 857·2223 | ·4157 | 55 | 53 | ·2606 | 208·253 |
| 9 | 910·6380 | ·4211 | 54 | 53 | ·2553 | 214·513 |
| 20 | 27964·0591 | ·4265 | 54 | 53 | ·2500 | 220·769 |
| 1 | 28017·4856 | ·4320 | 55 | 54 | ·2446 | 227·019 |
| 2 | 070·9176 | ·4374 | 54 | 53 | ·2393 | 233·263 |
| 3 | 124·3550 | ·4429 | 55 | 53 | ·2340 | 239·503 |
| 4 | 177·7979 | ·4484 | 55 | 54 | ·2286 | 245·737 |
| 5 | 231·2463 | ·4538 | 54 | 52 | ·2234 | 251·965 |
| 6 | 284·7001 | ·4592 | 54 | 54 | ·2180 | 258·189 |
| 7 | 338·1593 | ·4646 | 54 | 53 | ·2127 | 264·407 |
| 8 | 391·6239 | ·4701 | 55 | 54 | ·2073 | 270·619 |
| 9 | 445·0940 | ·4756 | 55 | 52 | ·2021 | 276·827 |
| 30 | 498·5696 | ·4809 | 53 | 53 | ·1968 | 283·029 |
| 1 | 552·0505 | ·4864 | 55 | 54 | ·1914 | 289·225 |
| 2 | 605·5369 | ·4918 | 54 | 53 | ·1861 | 295·417 |

| −52°. | Diff. | Δ². | Δ². | Diff. | 53°. | ′ | −53°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 30105·3525 | 53·6430 | 54 | 53 | 6·0383 | 157466·6296 | 0 | 33333·3704 | 53·9617 | 53 |
| 158·9955 | ·6484 | 54 | 53 | ·0330 | 472·6679 | 1 | 387·3321 | ·9670 | 53 |
| 212·6439 | ·6538 | 54 | 52 | ·0278 | 478·7009 | 2 | 441·2991 | ·9722 | 52 |
| 266·2977 | ·6591 | 53 | 52 | ·0226 | 484·7287 | 3 | 495·2713 | ·9774 | 52 |
| 319·9568 | ·6645 | 54 | 53 | ·0173 | 490·7513 | 4 | 549·2487 | ·9827 | 53 |
| 373·6213 | ·6698 | 53 | 52 | ·0121 | 496·7686 | 5 | 603·2314 | ·9879 | 52 |
| 427·2911 | ·6752 | 54 | 52 | ·0069 | 502·7807 | 6 | 657·2193 | ·9931 | 52 |
| 480·9663 | ·6806 | 54 | 53 | 6·0016 | 508·7876 | 7 | 711·2124 | 53·9984 | 53 |
| 534·6469 | ·6859 | 53 | 53 | 5·9963 | 514·7892 | 8 | 765·2108 | 54·0037 | 53 |
| 588·3328 | ·6913 | 54 | 51 | ·9912 | 520·7855 | 9 | 819·2145 | ·0088 | 51 |
| 642·0241 | ·6966 | 53 | 53 | ·9859 | 526·7767 | 10 | 873·2233 | ·0141 | 53 |
| 695·7207 | ·7020 | 54 | 53 | ·9806 | 532·7626 | 1 | 927·2374 | ·0194 | 53 |
| 749·4227 | ·7073 | 53 | 51 | ·9755 | 538·7432 | 2 | 33981·2568 | ·0245 | 51 |
| 803·1300 | ·7127 | 54 | 53 | ·9702 | 544·7187 | 3 | 34035·2813 | ·0298 | 53 |
| 856·8427 | ·7180 | 53 | 52 | ·9650 | 550·6889 | 4 | 089·3111 | ·0350 | 52 |
| 910·5607 | ·7233 | 53 | 52 | ·9598 | 556·6539 | 15 | 143·3461 | ·0402 | 52 |
| 30964·2840 | ·7287 | 54 | 53 | ·9545 | 562·6137 | 6 | 197·3863 | ·0455 | 53 |
| 31018·0127 | ·7341 | 54 | 51 | ·9494 | 568·5682 | 7 | 251·4318 | ·0506 | 51 |
| 071·7468 | ·7394 | 53 | 53 | ·9441 | 574·5176 | 8 | 305·4824 | ·0559 | 53 |
| 125·4862 | ·7447 | 53 | 52 | ·9389 | 580·4617 | 9 | 359·5383 | ·0611 | 52 |
| 179·2309 | ·7500 | 53 | 52 | ·9337 | 586·4006 | 20 | 413·5994 | ·0663 | 52 |
| 232·9809 | ·7554 | 53 | 52 | ·9285 | 592·3343 | 1 | 467·6657 | ·0715 | 52 |
| 286·7363 | ·7607 | 53 | 52 | ·9233 | 598·2628 | 2 | 521·7372 | ·0767 | 52 |
| 340·4970 | ·7660 | 53 | 52 | ·9181 | 604·1861 | 3 | 575·8139 | ·0819 | 53 |
| 394·2630 | ·7714 | 54 | 53 | ·9128 | 610·1042 | 4 | 629·8958 | ·0872 | 51 |
| 448·0344 | ·7766 | 52 | 51 | ·9077 | 616·0170 | 25 | 683·9830 | ·0923 | 52 |
| 501·8110 | ·7820 | 54 | 52 | ·9025 | 621·9247 | 6 | 738·0753 | ·0975 | 53 |
| 555·5930 | ·7873 | 53 | 53 | ·8972 | 627·8272 | 7 | 792·1728 | ·1028 | 51 |
| 609·3803 | ·7927 | 54 | 51 | ·8921 | 633·7244 | 8 | 846·2756 | ·1079 | 52 |
| 663·1730 | ·7979 | 52 | 52 | ·8869 | 639·6165 | 9 | 900·3835 | ·1131 | |
| 716·9709 | ·8032 | 53 | 52 | ·8817 | 645·5034 | 30 | 34954·4966 | ·1183 | 52 |
| 770·7741 | ·8086 | 54 | 52 | ·8765 | 651·3851 | 1 | 35008·6149 | ·1235 | 52 |
| 824·5827 | ·8139 | 53 | 51 | ·8714 | 657·2616 | 2 | 062·7384 | ·1286 | 51 |
| 878·3966 | ·8192 | 53 | 53 | ·8661 | 663·1330 | 3 | 116·8670 | ·1339 | 53 |
| 932·2158 | ·8245 | 53 | 51 | ·8610 | 668·9991 | 4 | 171·0009 | ·1390 | 51 |
| 31986·0403 | ·8298 | 53 | 53 | ·8557 | 674·8601 | 35 | 225·1399 | ·1443 | 53 |
| 32039·8701 | ·8350 | 52 | 51 | ·8506 | 680·7158 | 6 | 279·2842 | ·1494 | 51 |
| 093·7051 | ·8404 | 54 | 52 | ·8454 | 686·5664 | 7 | 333·4336 | ·1546 | 52 |
| 147·5455 | ·8457 | 53 | 51 | ·8403 | 692·4118 | 8 | 387·5882 | ·1597 | 51 |
| 201·3912 | ·8510 | 53 | 52 | ·8351 | 698·2521 | 9 | 441·7479 | ·1649 | 52 |
| 255·2422 | ·8563 | 53 | 52 | ·8299 | 704·0872 | 40 | 495·9128 | ·1701 | 52 |
| 309·0985 | ·8615 | 52 | 52 | ·8247 | 709·9171 | 1 | 550·0829 | ·1753 | 52 |
| 362·9600 | ·8669 | 54 | 51 | ·8196 | 715·7418 | 2 | 604·2582 | ·1804 | 51 |
| 416·8269 | ·8721 | 52 | 52 | ·8144 | 721·5614 | 3 | 658·4386 | ·1856 | 52 |
| 470·6990 | ·8774 | 53 | 52 | ·8092 | 727·3758 | 4 | 712·6242 | ·1908 | 52 |
| 524·5764 | ·8827 | 53 | 51 | ·8041 | 733·1850 | 45 | 766·8150 | ·1959 | 51 |
| 578·4591 | ·8880 | 53 | 52 | ·7989 | 738·9891 | 6 | 821·0109 | ·2011 | 52 |
| 632·3471 | ·8933 | 53 | 51 | ·7938 | 744·7880 | 7 | 875·2120 | ·2062 | 51 |
| 686·2404 | ·8985 | 52 | 52 | ·7886 | 750·5818 | 8 | 929·4182 | ·2114 | 52 |
| 740·1389 | ·9038 | 53 | 51 | ·7835 | 756·3704 | 9 | 35983·6296 | ·2165 | 51 |
| 794·0427 | ·9091 | 53 | 52 | ·7783 | 762·1539 | 50 | 36037·8461 | ·2217 | 52 |
| 847·9518 | ·9143 | 52 | 52 | ·7731 | 767·9322 | 1 | 092·0678 | ·2269 | 52 |
| 901·8661 | ·9196 | 53 | 51 | ·7680 | 773·7053 | 2 | 146·2947 | ·2320 | 51 |
| 32955·7857 | ·9249 | 53 | 51 | ·7629 | 779·4733 | 3 | 200·5267 | ·2371 | 51 |
| 33009·7106 | ·9302 | 53 | 51 | ·7578 | 785·2362 | 4 | 254·7638 | ·2422 | 51 |
| 063·6408 | ·9354 | 52 | 52 | ·7526 | 790·9940 | 55 | 309·0060 | ·2474 | 52 |
| 117·5762 | ·9407 | 53 | 52 | ·7474 | 796·7466 | 6 | 363·2534 | ·2526 | 52 |
| 171·5169 | ·9459 | 52 | 51 | ·7423 | 802·4940 | 7 | 417·5060 | ·2577 | 51 |
| 225·4628 | ·9512 | 53 | 51 | ·7372 | 808·2363 | 8 | 471·7637 | ·2628 | 51 |
| 279·4140 | 53·9564 | 52 | 51 | 5·7321 | 813·9735 | 9 | 526·0265 | 54·2679 | 51 |
| 33333·3704 | | | | | 157819·7056 | 60 | 36580·2944 | | |

| | | −54°. | Diff. | Δ². | Δ¹. | Diff. | 55°. |
|---|---|---|---|---|---|---|---|
| | | " | " | | | " | " |
| 056 | 0 | 36580·2944 | 54·2731 | 52 | 49 | 5·4230 | 158154·31 |
| 325 | 1 | 634·5675 | ·2782 | 51 | 51 | ·4179 | 159·73 |
| 543 | 2 | 688·8457 | ·2833 | 51 | 49 | ·4130 | 165·15 |
| 710 | 3 | 743·1290 | ·2885 | 52 | 51 | ·4079 | 170·57 |
| 825 | 4 | 797·4175 | ·2935 | 50 | 50 | ·4029 | 175·97 |
| 890 | 5 | 851·7110 | ·2987 | 52 | 49 | ·3980 | 181·38 |
| 903 | 6 | 906·0097 | ·3038 | 51 | 51 | ·3929 | 186·77 |
| 865 | 7 | 36960·3135 | ·3090 | 52 | 49 | ·3880 | 192·17 |
| 775 | 8 | 37014·6225 | ·3140 | 50 | 51 | ·3829 | 197·55 |
| 635 | 9 | 068·9365 | ·3191 | 51 | 49 | ·3780 | 202·94 |
| 444 | 10 | 123·2556 | ·3243 | 52 | 50 | ·3730 | 208·32 |
| 201 | 1 | 177·5799 | ·3294 | 51 | 50 | ·3680 | 213·69 |
| 907 | 2 | 231·9093 | ·3344 | 50 | 49 | ·3631 | 219·06 |
| 563 | 3 | 286·2437 | ·3396 | 52 | 51 | ·3580 | 224·42 |
| 167 | 4 | 340·5833 | ·3447 | 51 | 49 | ·3531 | 229·78 |
| 720 | 15 | 394·9280 | ·3497 | 50 | 50 | ·3481 | 235·13 |
| 223 | 6 | 449·2777 | ·3549 | 52 | 50 | ·3431 | 240·48 |
| 674 | 7 | 503·6326 | ·3600 | 51 | 49 | ·3382 | 245·82 |
| 074 | 8 | 557·9926 | ·3650 | 50 | 50 | ·3332 | 251·16 |
| 424 | 9 | 612·3576 | ·3701 | 51 | 50 | ·3282 | 256·49 |
| 723 | 20 | 666·7277 | ·3753 | 52 | 49 | ·3233 | 261·82 |
| 970 | 1 | 721·1030 | ·3803 | 50 | 50 | ·3183 | 267·15 |
| 167 | 2 | 775·4833 | ·3854 | 51 | 50 | ·3133 | 272·48 |
| 313 | 3 | 829·8687 | ·3905 | 51 | 49 | ·3084 | 277·81 |
| 408 | 4 | 884·2592 | ·3955 | 50 | 50 | ·3034 | 283·09 |
| 453 | 25 | 938·6547 | ·4007 | 52 | 49 | ·2985 | 288·39 |
| 446 | 6 | 37993·0554 | ·4057 | 50 | 50 | ·2935 | 293·69 |
| 389 | 7 | 38047·4611 | ·4108 | 51 | 49 | ·2886 | 298·98 |
| 281 | 8 | 101·8719 | ·4158 | 50 | 49 | ·2837 | 304·27 |
| 123 | 9 | 156·2877 | ·4210 | 52 | 50 | ·2787 | 309·55 |
| 913 | 30 | 210·7087 | ·4260 | 50 | 50 | ·2737 | 314·83 |
| 653 | 1 | 265·1347 | ·4310 | 50 | 49 | ·2688 | 320·11 |
| 343 | 2 | 319·5657 | | 52 | 49 | | 325·38 |





| −55°. | Diff. | Δ². | Δ². | Diff. | 56°. | ′ | −56°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 39845·6838 | | | 48 | | 158470·9079 | 0 | 43129·0921 | | 48 |
| 900·2608 | 54·5770 | 49 | | 5·1265 | 476·0344 | 1 | 183·9656 | 54·8735 | |
| 39954·8429 | ·5821 | 51 | 50 | ·1215 | 481·1559 | 2 | 238·8441 | ·8785 | 50 |
| 40009·4299 | ·5870 | 49 | 48 | ·1167 | 486·2726 | 3 | 293·7274 | ·8833 | 48 |
| 064·0220 | ·5921 | 51 | 49 | ·1118 | 491·3844 | 4 | 348·6156 | ·8882 | 49 |
| 118·6191 | ·5971 | 50 | 48 | ·1070 | 496·4914 | 5 | 403·5086 | ·8930 | 48 |
| 173·2211 | ·6020 | 49 | 50 | ·1020 | 501·5934 | 6 | 458·4066 | ·8980 | 50 |
| 227·8282 | ·6071 | 51 | 48 | ·0972 | 506·6906 | 7 | 513·3094 | ·9028 | 48 |
| 282·4402 | ·6120 | 49 | 49 | ·0923 | 511·7829 | 8 | 568·2171 | ·9077 | 49 |
| 337·0573 | ·6171 | 51 | 48 | ·0875 | 516·8704 | 9 | 623·1296 | ·9125 | 48 |
| | ·6220 | 49 | 49 | ·0826 | | | | ·9174 | 49 |
| 391·6793 | | | 48 | | 521·9530 | 10 | 678·0470 | | 48 |
| 446·3063 | ·6270 | 50 | 49 | ·0778 | 527·0308 | 1 | 732·9692 | ·9222 | 49 |
| 500·9383 | ·6320 | 50 | 49 | ·0729 | 532·1037 | 2 | 787·8963 | ·9271 | 49 |
| 555·5752 | ·6369 | 49 | 48 | ·0680 | 537·1717 | 3 | 842·8283 | ·9320 | 48 |
| 610·2172 | ·6420 | 51 | 49 | ·0632 | 542·2349 | 4 | 897·7651 | ·9368 | 49 |
| 664·8641 | ·6469 | 49 | 48 | ·0583 | 547·2932 | 15 | 43952·7068 | ·9417 | 48 |
| 719·5160 | ·6519 | 50 | 48 | ·0535 | 552·3467 | 6 | 44007·6533 | ·6465 | 48 |
| 774·1729 | ·6569 | 50 | 49 | ·0487 | 557·3954 | 7 | 062·6046 | ·9513 | 48 |
| 828·8347 | ·6618 | 49 | 49 | ·0438 | 562·4392 | 8 | 117·5608 | ·9562 | 49 |
| 883·5015 | ·6668 | 50 | 49 | ·0389 | 567·4781 | 9 | 172·5219 | ·9611 | 49 |
| | ·6718 | 50 | 48 | ·0341 | | | | ·9659 | 48 |
| 938·1733 | | | 48 | | 572·5122 | 20 | 227·4878 | | 48 |
| 40992·8500 | ·6767 | 49 | 48 | ·0293 | 577·5415 | 1 | 282·4585 | ·9707 | 48 |
| 41047·5317 | ·6817 | 50 | 49 | ·0245 | 582·5660 | 2 | 337·4340 | ·9755 | 49 |
| 102·2184 | ·6867 | 50 | 49 | ·0196 | 587·5856 | 3 | 392·4144 | ·9804 | 49 |
| 156·9100 | ·6916 | 49 | 47 | ·0147 | 592·6003 | 4 | 447·3997 | ·9853 | 47 |
| 211·6066 | ·6966 | 50 | 49 | ·0100 | 597·6103 | 25 | 502·3897 | ·9900 | 49 |
| 266·3081 | ·7015 | 49 | 48 | ·0051 | 602·6154 | 6 | 557·3846 | ·9949 | 48 |
| 321·0146 | ·7065 | 50 | 48 | 5·0003 | 607·6157 | 7 | 612·3843 | 54·9997 | 48 |
| 375·7260 | ·7114 | 49 | 49 | 4·9955 | 612·6112 | 8 | 667·3888 | 55·0045 | 48 |
| 430·4423 | ·7163 | 49 | 47 | ·9906 | 617·6018 | 9 | 722·3982 | ·0094 | 49 |
| | ·7213 | 50 | | ·9859 | | | | ·0141 | 47 |
| 485·1636 | | | 49 | | 622·5877 | 30 | 777·4123 | | 49 |
| 539·8899 | ·7263 | 50 | 48 | ·9810 | 627·5687 | 1 | 832·4313 | ·0190 | 48 |
| 594·6211 | ·7312 | 49 | 48 | ·9762 | 632·5449 | 2 | 887·4551 | ·0238 | 48 |
| 649·3572 | ·7361 | 49 | 49 | ·9714 | 637·5163 | 3 | 942·4837 | ·0286 | 49 |
| 704·0983 | ·7411 | 50 | 47 | ·9665 | 642·4828 | 4 | 44997·5172 | ·0335 | 47 |
| 758·8443 | ·7466 | 49 | 48 | ·9618 | 647·4446 | 35 | 45052·5554 | ·0382 | 48 |
| 813·5953 | ·7510 | 50 | 48 | ·9570 | 652·4016 | 6 | 107·5984 | ·0430 | 48 |
| 868·3511 | ·7558 | 48 | 49 | ·9522 | 657·3538 | 7 | 162·6462 | ·0478 | 49 |
| 923·1119 | ·7608 | 50 | 47 | ·9473 | 662·3011 | 8 | 217·6989 | ·0527 | 47 |
| 41977·8777 | ·7658 | 50 | 49 | ·9426 | 667·2437 | 9 | 272·7563 | ·0574 | 47 |
| | ·7706 | 48 | | ·9377 | | | | ·0623 | 49 |
| 42032·6483 | | | 47 | | 672·1814 | 40 | 327·8186 | | 47 |
| 087·4239 | ·7756 | 50 | 48 | ·9330 | 677·1144 | 1 | 382·8856 | ·0670 | 48 |
| 142·2044 | ·7805 | 49 | 48 | ·9282 | 682·0426 | 2 | 437·9574 | ·0718 | 48 |
| 196·9898 | ·7854 | 49 | 48 | ·9234 | 686·9660 | 3 | 493·0340 | ·0766 | 48 |
| 251·7801 | ·7903 | 49 | 48 | ·9186 | 691·8846 | 4 | 548·1154 | ·0814 | 48 |
| 306·5753 | ·7952 | 49 | 48 | ·9138 | 696·7984 | 45 | 603·2016 | ·0862 | 48 |
| 361·3755 | ·8002 | 50 | 48 | ·9090 | 701·7074 | 6 | 658·2926 | ·0910 | 48 |
| 416·1805 | ·8050 | 48 | 48 | ·9042 | 706·6116 | 7 | 713·3884 | ·0958 | 48 |
| 470·9905 | ·8100 | 50 | 47 | ·8995 | 711·5111 | 8 | 768·4889 | ·1005 | 47 |
| 525·8054 | ·8149 | 49 | 48 | ·8947 | 716·4058 | 9 | 823·5942 | ·1053 | 48 |
| | ·8197 | 48 | 48 | ·8899 | | | | ·1101 | 48 |
| 580·6251 | | | 48 | | 721·2957 | 50 | 878·7043 | | 48 |
| 635·4498 | ·8247 | 50 | 47 | ·8851 | 726·1808 | 1 | 933·8192 | ·1149 | 47 |
| 690·2794 | ·8296 | 49 | 48 | ·8804 | 731·0612 | 2 | 45988·9388 | ·1196 | 48 |
| 745·1138 | ·8344 | 48 | 48 | ·8756 | 735·9368 | 3 | 46044·0632 | ·1244 | 48 |
| 799·9532 | ·8394 | 50 | 48 | ·8708 | 740·8076 | 4 | 099·1924 | ·1292 | 48 |
| 854·7975 | ·8443 | 49 | 47 | ·8660 | 745·6736 | 55 | 154·3264 | ·1340 | 48 |
| 909·6466 | ·8491 | 48 | 47 | ·8613 | 750·5349 | 6 | 209·4651 | ·1387 | 47 |
| 42964·5007 | ·8541 | 50 | 48 | ·8566 | 755·3915 | 7 | 264·6085 | ·1434 | 47 |
| 43019·3596 | ·8589 | 48 | 48 | ·8518 | 760·2433 | 8 | 319·7567 | ·1482 | 48 |
| 074·2234 | ·8638 | 49 | 48 | ·8470 | 765·0903 | 9 | 374·9097 | ·1530 | 48 |
| 43129·0921 | 54·8687 | 49 | | 4·8422 | 158769·9325 | 60 | 46430·0675 | 55·1578 | 48 |

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*Mr. Allis,* LXII. 9.

| | | $-\sigma^5$. | Diff. | $A^1$. | $A^2$. | Diff. | $s\beta^5$. |
|---|---|---|---|---|---|---|---|
| | | | | | | | 159951·8477 |
| 5 | 0 | 464300·0675 | 55·1625 | 47 | 47 | 4·5562 | 956·4039 |
| 6 | 0 | 285·2300 | ·1672 | 47 | 46 | ·5516 | 960·9555 |
| 7 | 0 | 548·3974 | ·1720 | 48 | 46 | ·5470 | 965·5025 |
| 8 | 0 | 595·5692 | ·1768 | 48 | 46 | ·5424 | 970·0449 |
| 9 | 0 | 630·7460 | ·1815 | 47 | 46 | ·5378 | 974·5827 |
| 10 | 0 | 705·9275 | ·1862 | 47 | 46 | ·5332 | 979·1159 |
| 11 | 0 | 761·1137 | ·1909 | 47 | 46 | ·5285 | 983·6443 |
| 12 | 0 | 816·3046 | ·1957 | 48 | 46 | ·5239 | 988·1682 |
| 13 | 0 | 871·5003 | ·2005 | 48 | 45 | ·5194 | 992·6876 |
| 14 | 0 | 926·7008 | ·2051 | 46 | 47 | ·5147 | |
| 15 | 0 | 982·0059 | ·2099 | 48 | 46 | ·5101 | 997·2023 |
| 16 | 1 | 037·3158 | ·2147 | 48 | 46 | ·5055 | 1001·7124 |
| 17 | 1 | 092·6305 | ·2194 | 47 | 46 | ·5009 | 1006·2179 |
| 18 | 1 | 147·9499 | ·2240 | 46 | 45 | ·4964 | 1010·7188 |
| 19 | 1 | 203·2739 | ·2288 | 48 | 47 | ·4917 | 1015·2148 |
| 20 | 1 | 258·6027 | ·2336 | 48 | 46 | ·4871 | 1019·7063 |
| 21 | 1 | 313·9363 | ·2382 | 46 | 45 | ·4826 | 1024·1936 |
| 22 | 1 | 369·2745 | ·2430 | 48 | 47 | ·4779 | 1028·6762 |
| 23 | 1 | 424·6175 | ·2477 | 47 | 45 | ·4734 | 1033·1541 |
| 24 | 1 | 479·9652 | ·2524 | 47 | 46 | ·4688 | 1037·6273 |
| 25 | 1 | 535·3176 | ·2571 | 47 | 46 | ·4642 | 1042·0963 |
| 26 | 1 | 590·6747 | ·2618 | 47 | 46 | ·4596 | 1046·5605 |
| 27 | 2 | 646·0365 | ·2665 | 47 | 45 | ·4551 | 1051·0201 |
| 28 | 2 | 701·4030 | ·2712 | 47 | 46 | ·4505 | 1055·4752 |
| 29 | 2 | 756·7742 | ·2759 | 47 | 46 | ·4459 | 1059·9257 |
| 30 | 2 | 812·1501 | ·2807 | 48 | 46 | ·4413 | 1064·3716 |
| 31 | 2 | 867·5308 | ·2853 | 46 | 45 | ·4368 | 1068·8129 |
| 32 | 2 | 922·9161 | ·2900 | 47 | 46 | ·4322 | 1073·2497 |
| 33 | 2 | 978·3061 | ·2947 | 47 | 46 | ·4276 | 1077·6819 |
| 34 | 3 | 033·7008 | ·2994 | 47 | 45 | ·4231 | 1082·1095 |
| 35 | 3 | 089·1002 | ·3041 | 47 | 46 | ·4185 | 1086·5326 |
| 36 | 3 | 144·5043 | ·3088 | 47 | 45 | ·4140 | 1090·9511 |
| 37 | 3 | 199·9131 | ·3134 | 46 | 46 | ·4094 | 1095·3651 |



5-9



| −58°. | Diff. | Δ². | Δ². | Diff. | 59°. | ′ | −59° | Diff. | Δ² |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 49748·1528 | 55·4438 | 47 | 46 | 4·2827 | 159317·1144 | 0 | 53082·8856 | 55·7173 | 46 |
| 803·5966 | ·4484 | 46 | 45 | ·2782 | 321·3971 | 1 | 138·6029 | ·7218 | 45 |
| 859·0450 | ·4530 | 46 | 44 | ·2738 | 325·6753 | 2 | 194·3247 | ·7262 | 44 |
| 914·4980 | ·4576 | 46 | 46 | ·2692 | 329·9491 | 3 | 250·0509 | ·7308 | 46 |
| 49969·9556 | ·4622 | 46 | 44 | ·2648 | 334·2183 | 4 | 305·7817 | ·7352 | 44 |
| 50025·4178 | ·4668 | 46 | 45 | ·2603 | 338·4831 | 5 | 361·5169 | ·7397 | 45 |
| 080·8846 | ·4715 | 47 | 45 | ·2558 | 342·7434 | 6 | 417·2566 | ·7442 | 45 |
| 136·3561 | ·4761 | 46 | 44 | ·2514 | 346·9992 | 7 | 473·0008 | ·7486 | 44 |
| 191·8322 | ·4806 | 45 | 46 | ·2468 | 351·2506 | 8 | 528·7494 | ·7532 | 46 |
| 247·3128 | ·4853 | 47 | 44 | ·2424 | 355·4974 | 9 | 584·5026 | ·7576 | 44 |
| 302·7981 | ·4899 | 46 | 45 | ·2379 | 359·7398 | 10 | 640·2602 | ·7621 | 45 |
| 358·2880 | ·4945 | 46 | 44 | ·2335 | 363·9777 | 1 | 696·0223 | ·7665 | 44 |
| 413·7825 | ·4991 | 46 | 46 | ·2289 | 368·2112 | 2 | 751·7888 | ·7711 | 46 |
| 469·2816 | ·5036 | 45 | 44 | ·2245 | 372·4401 | 3 | 807·5599 | ·7755 | 44 |
| 524·7852 | ·5083 | 47 | 44 | ·2201 | 376·6646 | 4 | 863·3354 | ·7799 | 44 |
| 580·2935 | ·5129 | 46 | 45 | ·2156 | 380·8847 | 15 | 919·1153 | ·7844 | 45 |
| 635·8064 | ·5174 | 45 | 45 | ·2111 | 385·1003 | 6 | 53974·8997 | ·7889 | 45 |
| 691·3238 | ·5221 | 47 | 45 | ·2066 | 389·3114 | 7 | 54030·6886 | ·7934 | 45 |
| 746·8459 | ·5266 | 45 | 44 | ·2022 | 393·5180 | 8 | 086·4820 | ·7978 | 44 |
| 802·3725 | ·5312 | 46 | 44 | ·1978 | 397·7202 | 9 | 142·2798 | ·8022 | 44 |
| 857·9037 | ·5358 | 46 | 45 | ·1933 | 401·9180 | 20 | 198·0820 | ·8067 | 45 |
| 913·4395 | ·5404 | 46 | 45 | ·1888 | 406·1113 | 1 | 253·8887 | ·8112 | 45 |
| 50968·9799 | ·5449 | 45 | 44 | ·1844 | 410·3001 | 2 | 309·6999 | ·8156 | 44 |
| 51024·5248 | ·5495 | 46 | 44 | ·1800 | 414·4845 | 3 | 365·5155 | ·8200 | 44 |
| 080·0743 | ·5541 | 46 | 45 | ·1755 | 418·6645 | 4 | 421·3355 | ·8245 | 45 |
| 135·6284 | ·5587 | 46 | 44 | ·1711 | 422·8400 | 25 | 477·1600 | ·8289 | 44 |
| 191·1871 | ·5632 | 45 | 45 | ·1666 | 427·0111 | 6 | 532·9889 | ·8334 | 45 |
| 246·7503 | ·5678 | 46 | 44 | ·1622 | 431·1777 | 7 | 588·8223 | ·8378 | 44 |
| 302·3181 | ·5724 | 46 | 44 | ·1578 | 435·3399 | 8 | 644·6601 | ·8422 | 44 |
| 357·8905 | ·5769 | 45 | 45 | ·1533 | 439·4977 | 9 | 700·5023 | ·8467 | 45 |
| 413·4674 | ·5815 | 46 | 44 | ·1489 | 443·6510 | 30 | 756·3490 | ·8511 | 44 |
| 469·0489 | ·5860 | 45 | 44 | ·1445 | 447·7999 | 1 | 812·2001 | ·8555 | 44 |
| 524·6349 | ·5906 | 46 | 44 | ·1401 | 451·9444 | 2 | 868·0556 | ·8599 | 44 |
| 580·2255 | ·5952 | 46 | 45 | ·1356 | 456·0845 | 3 | 923·9155 | ·8644 | 45 |
| 635·8207 | ·5997 | 45 | 43 | ·1313 | 460·2201 | 4 | 54979·7799 | ·8687 | 43 |
| 691·4204 | ·6042 | 45 | 45 | ·1268 | 464·3514 | 35 | 55035·6486 | ·8732 | 45 |
| 747·0246 | ·6088 | 46 | 45 | ·1223 | 468·4782 | 6 | 091·5218 | ·8777 | 45 |
| 802·6334 | ·6134 | 46 | 43 | ·1180 | 472·6005 | 7 | 147·3995 | ·8820 | 43 |
| 858·2468 | ·6179 | 45 | 44 | ·1136 | 476·7185 | 8 | 203·2815 | ·8864 | 44 |
| 913·8647 | ·6224 | 45 | 45 | ·1091 | 480·8321 | 9 | 259·1679 | ·8909 | 45 |
| 51969·4871 | ·6269 | 45 | 44 | ·1047 | 484·9412 | 40 | 315·0588 | ·8953 | 44 |
| 52025·1140 | ·6315 | 46 | 43 | ·1004 | 489·0459 | 1 | 370·9541 | ·8996 | 43 |
| 080·7455 | ·6361 | 46 | 45 | ·0959 | 493·1463 | 2 | 426·8537 | ·9041 | 45 |
| 136·3816 | ·6405 | 44 | 43 | ·0916 | 497·2422 | 3 | 482·7578 | ·9084 | 43 |
| 192·0221 | ·6451 | 46 | 45 | ·0871 | 501·3338 | 4 | 538·6662 | ·9129 | 45 |
| 247·6672 | ·6496 | 45 | 44 | ·0827 | 505·4209 | 45 | 594·5791 | ·9173 | 44 |
| 303·3168 | ·6542 | 46 | 43 | ·0784 | 509·5036 | 6 | 650·4964 | ·9216 | 43 |
| 358·9710 | ·6586 | 44 | 45 | ·0739 | 513·5820 | 7 | 706·4180 | ·9261 | 45 |
| 414·6296 | ·6632 | 46 | 44 | ·0695 | 517·6559 | 8 | 762·3441 | ·9305 | 44 |
| 470·2928 | ·6677 | 45 | 43 | ·0652 | 521·7254 | 9 | 818·2746 | ·9348 | 43 |
| 525·9605 | ·6723 | 46 | 44 | ·0608 | 525·7906 | 50 | 874·2094 | ·9392 | 44 |
| 581·6328 | ·6767 | 44 | 44 | ·0564 | 529·8514 | 1 | 930·1486 | ·9436 | 44 |
| 637·3095 | ·6812 | 45 | 43 | ·0521 | 533·9078 | 2 | 55986·0922 | ·9479 | 43 |
| 692·9907 | ·6858 | 46 | 45 | ·0476 | 537·9599 | 3 | 56042·0401 | ·9524 | 45 |
| 748·6765 | ·6903 | 45 | 43 | ·0433 | 542·0075 | 4 | 097·9925 | ·9567 | 43 |
| 804·3668 | ·6948 | 45 | 44 | ·0389 | 546·0508 | 55 | 153·9492 | ·9611 | 44 |
| 860·0616 | ·6992 | 44 | 44 | ·0345 | 550·0897 | 6 | 209·9103 | ·9655 | 44 |
| 915·7608 | ·7038 | 46 | 44 | ·0301 | 554·1242 | 7 | 265·8758 | ·9699 | 44 |
| 52971·4646 | ·7083 | 45 | 43 | ·0258 | 558·1543 | 8 | 321·8457 | ·9742 | 43 |
| 53027·1729 | 55·7127 | 44 | 43 | 4·0215 | 562·1801 | 9 | 377·8199 | 55·9785 | 43 |
| 53082·8856 | | | | | 159566·2016 | 60 | 56433·7984 | | |

| | ′ | −60°. | Diff. | Δ′. | Δ′. | Diff. | 0′ |
|---|---|---|---|---|---|---|---|
| | | ″ | | | | | ″ |
| 16 | 0 | 56433·7984 | | 45 | 42 | | 3 59799·581 |
| 36 | 1 | 489·7814 | 55·9830 | 43 | 43 | 3·7393 | 803·340 |
| 13 | 2 | 545·7687 | ·9873 | 44 | 41 | ·7550 | 807·096 |
| 56 | 3 | 601·7604 | ·9917 | 43 | 43 | ·7509 | 810·846 |
| 36 | 4 | 657·7564 | 55·9960 | 43 | 42 | ·7466 | 814·591 |
| 33 | 5 | 713·7567 | 56·0003 | 45 | 42 | ·7424 | 818·335 |
| 85 | 6 | 769·7615 | ·0048 | 43 | 43 | ·7382 | 822·073 |
| 94 | 7 | 825·7706 | ·0091 | 43 | 41 | ·7339 | 825·807 |
| 60 | 8 | 881·7840 | ·0134 | 44 | 43 | ·7298 | 829·537 |
| 82 | 9 | 937·8018 | ·0178 | 43 | 42 | ·7255 | 833·262 |
| | | | ·0221 | | | ·7213 | |
| 61 | 10 | 56993·8239 | ·0264 | 43 | 42 | ·7171 | 836·984 |
| 97 | 1 | 57049·8503 | ·0308 | 44 | 42 | ·7129 | 840·700 |
| 89 | 2 | 105·8811 | ·0352 | 44 | 42 | ·7087 | 844·414 |
| 37 | 3 | 161·9163 | ·0394 | 42 | 42 | ·7045 | 848·122 |
| 43 | 4 | 217·9557 | ·0438 | 44 | 42 | ·7003 | 851·827 |
| 05 | 15 | 273·9995 | ·0481 | 43 | 42 | ·6961 | 855·527 |
| 24 | 6 | 330·0476 | ·0525 | 44 | 42 | ·6919 | 859·223 |
| 99 | 7 | 386·1001 | ·0568 | 43 | 42 | ·6877 | 862·915 |
| 31 | 8 | 442·1569 | ·0611 | 43 | 42 | ·6835 | 866·603 |
| 20 | 9 | 498·2180 | ·0654 | 43 | 41 | ·6794 | 870·288 |
| 66 | 20 | 554·2834 | ·0698 | 44 | 43 | ·6751 | 873·966 |
| 68 | 1 | 610·3532 | ·0740 | 42 | 41 | ·6710 | 877·641 |
| 28 | 2 | 666·4272 | ·0784 | 44 | 42 | ·6668 | 881·312 |
| 44 | 3 | 722·5056 | ·0827 | 43 | 42 | ·6626 | 884·979 |
| 17 | 4 | 778·5883 | ·0870 | 43 | 42 | ·6584 | 888·641 |
| 47 | 25 | 834·6753 | ·0913 | 43 | 42 | ·6542 | 892·300 |
| 34 | 6 | 890·7666 | ·0956 | 43 | 41 | ·6501 | 895·954 |
| 78 | 7 | 57946·8622 | ·0999 | 43 | 42 | ·6459 | 899·604 |
| 79 | 8 | 58002·9621 | ·1043 | 44 | 42 | ·6417 | 903·250 |
| 36 | 9 | 059·0664 | ·1085 | 42 | 41 | ·6376 | 906·892 |
| 51 | 30 | 115·1749 | ·1128 | 43 | 42 | ·6334 | 910·529 |
| 23 | 1 | 171·2877 | ·1171 | 43 | 41 | ·6293 | 914·163 |
| 52 | 2 | 227·4048 | ·1214 | 43 | 42 | ·6251 | 917·792 |



62



| ′ | −61°. | Diff. | Δ². | Δ². | Diff. | 62°. | ′ | −62°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|---|
| | ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 0 | 59800·4188 | 56·2407 | 42 | 42 | 3·5095 | 160017·7305. | 0 | 63182·2695 | 56·4905 | 42 |
| 1 | 856·6595 | ·2450 | 43 | 41 | ·5054 | 021·2400 | 1 | 238·7600 | ·4946 | 41 |
| 2 | 912·9045. | ·2491 | 41 | 40 | ·5014 | 024·7454 | 2 | 295·2546 | ·4986 | 40 |
| 3 | 59969·1536 | ·2534 | 43 | 42 | ·4972 | 028·2468 | 3 | 351·7532 | ·5028 | 42 |
| 4 | 60025·4070 | ·2576 | 42 | 40 | ·4932 | 031·7440 | 4 | 408·2560 | ·5068 | 40 |
| 5 | 081·6646 | ·2618 | 42 | 42 | ·4890 | 035·2372 | 5 | 464·7628 | ·5110 | 42 |
| 6 | 137·9264 | ·2661 | 43 | 40 | ·4850 | 038·7262 | 6 | 521·2738 | ·5150 | 40 |
| 7 | 194·1925. | ·2702 | 41 | 41 | ·4809 | 042·2112 | 7 | 577·7888 | ·5191 | 41 |
| 8 | 250·4627 | ·2745 | 43 | 40 | ·4769 | 045·6921 | 8 | 634·3079 | ·5231 | 40 |
| 9 | 306·7372 | ·2787 | 42 | 42 | ·4727 | 049·1690 | 9 | 690·8310 | ·5273 | 42 |
| 10 | 363·0159 | ·2829 | 42 | 40 | ·4687 | 052·6417 | 10 | 747·3583 | ·5313 | 40 |
| 1 | 419·2988 | ·2871 | 42 | 41 | ·4646 | 056·1104 | 1 | 803·8896 | ·5354 | 41 |
| 2 | 475·5859 | ·2913 | 42 | 41 | ·4605 | 059·5750. | 2 | 860·4250 | ·5395 | 41 |
| 3 | 531·8772 | ·2955 | 42 | 40 | ·4565 | 063·0355 | 3 | 916·9645. | ·5435 | 40 |
| 4 | 588·1727 | ·2997 | 42 | 41 | ·4524 | 066·4920 | 4 | 63973·5080 | ·5476 | 41 |
| 15 | 644·4724 | ·3039 | 42 | 41 | ·4483 | 069·9444 | 15 | 64030·0556 | ·5517 | 41 |
| 6 | 700·7763 | ·3081 | 42 | 40 | ·4443 | 073·3927 | 6 | 086·6073 | ·5557 | 40 |
| 7 | 757·0844 | ·3123 | 42 | 41 | ·4402 | 076·8370 | 7 | 143·1630 | ·5598 | 41 |
| 8 | 813·3967 | ·3165 | 42 | 40 | ·4362 | 080·2772 | 8 | 199·7228 | ·5638 | 40 |
| 9 | 869·7132 | ·3206 | 41 | 41 | ·4321 | 083·7134 | 9 | 256·2866 | ·5679 | 41 |
| 20 | 926·0338 | ·3249 | 43 | 40 | ·4281 | 087·1455 | 20 | 312·8545. | ·5719 | 40 |
| 1 | 60982·3587 | ·3290 | 41 | 41 | ·4240 | 090·5736 | 1 | 369·4264 | ·5760 | 41 |
| 2 | 61038·6877 | ·3332 | 42 | 41 | ·4199 | 093·9976 | 2 | 426·0024 | ·5801 | 41 |
| 3 | 095·0209 | ·3374 | 42 | 40 | ·4159 | 097·4175 | 3 | 482·5825. | ·5841 | 40 |
| 4 | 151·3583 | ·3416 | 42 | 40 | ·4119 | 100·8334 | 4 | 539·1666 | ·5881 | 40 |
| 25 | 207·6999 | ·3458 | 42 | 40 | ·4079 | 104·2453 | 25 | 595·7547 | ·5921 | 40 |
| 6 | 264·0457 | ·3499 | 41 | 41 | ·4038 | 107·6532 | 6 | 652·3468 | ·5962 | 41 |
| 7 | 320·3956 | ·3541 | 42 | 41 | ·3997 | 111·0570 | 7 | 708·9430 | ·6003 | 41 |
| 8 | 376·7497 | ·3583 | 42 | 40 | ·3957 | 114·4567 | 8 | 765·5433 | ·6043 | 40 |
| 9 | 433·1080 | ·3624 | 41 | 40 | ·3917 | 117·8524 | 9 | 822·1476 | ·6083 | 40 |
| 30 | 489·4704 | ·3666 | 42 | 40 | ·3877 | 121·2441 | 30 | 878·7559 | ·6123 | 40 |
| 1 | 545·8370 | ·3707 | 41 | 41 | ·3836 | 124·6318 | 1 | 935·3682 | ·6164 | 41 |
| 2 | 602·2077 | ·3749 | 42 | 40 | ·3796 | 128·0154 | 2 | 64991·9846 | ·6204 | 40 |
| 3 | 658·5826 | ·3791 | 42 | 40 | ·3756 | 131·3950 | 3 | 65048·6050. | ·6244 | 40 |
| 4 | 714·9617 | ·3833 | 42 | 40 | ·3716 | 134·7706 | 4 | 105·2294 | ·6284 | 40 |
| 35 | 771·3450. | ·3874 | 41 | 41 | ·3675 | 138·1422 | 35 | 161·8578 | ·6325 | 41 |
| 6 | 827·7324 | ·3915 | 41 | 39 | ·3636 | 141·5097 | 6 | 218·4903 | ·6364 | 39 |
| 7 | 884·1239 | ·3957 | 42 | 41 | ·3595 | 144·8733 | 7 | 275·1267 | ·6405 | 41 |
| 8 | 940·5196 | ·3998 | 41 | 40 | ·3555 | 148·2328 | 8 | 331·7672 | ·6445 | 40 |
| 9 | 61996·9194 | ·4039 | 41 | 40 | ·3515 | 151·5883 | 9 | 388·4117 | ·6485 | 40 |
| 40 | 62053·3233 | ·4081 | 42 | 40 | ·3475 | 154·9398 | 40 | 445·0602 | ·6525 | 40 |
| 1 | 109·7314 | ·4123 | 42 | 41 | ·3434 | 158·2873 | 1 | 501·7127 | ·6566 | 41 |
| 2 | 166·1437 | ·4164 | 41 | 39 | ·3395 | 161·6307 | 2 | 558·3693 | ·6605 | 39 |
| 3 | 222·5601 | ·4205 | 41 | 40 | ·3355 | 164·9702 | 3 | 615·0298 | ·6645 | 40 |
| 4 | 278·9806 | ·4247 | 42 | 40 | ·3315 | 168·3057 | 4 | 671·6943 | ·6685 | 40 |
| 45 | 335·4053 | ·4288 | 41 | 40 | ·3275 | 171·6372 | 45 | 728·3628 | ·6725 | 40 |
| 6 | 391·8341 | ·4329 | 41 | 40 | ·3235 | 174·9647 | 6 | 785·0353 | ·6765 | 40 |
| 7 | 448·2670 | ·4370 | 41 | 40 | ·3195 | 178·2882 | 7 | 841·7118 | ·6805 | 40 |
| 8 | 504·7040 | ·4412 | 42 | 40 | ·3155 | 181·6077 | 8 | 898·3923 | ·6845 | 40 |
| 9 | 561·1452 | ·4453 | 41 | 40 | ·3115 | 184·9232 | 9 | 65955·0768 | ·6885 | 40 |
| 50 | 617·5905. | ·4494 | 41 | 39 | ·3076 | 188·2347 | 50 | 66011·7653 | ·6924 | 39 |
| 1 | 674·0399 | ·4535 | 41 | 41 | ·3035 | 191·5423 | 1 | 068·4577 | ·6965 | 41 |
| 2 | 730·4934 | ·4576 | 41 | 39 | ·2996 | 194·8458 | 2 | 125·1542 | ·7004 | 39 |
| 3 | 786·9510 | ·4618 | 42 | 40 | ·2956 | 198·1454 | 3 | 181·8546 | ·7044 | 40 |
| 4 | 843·4128 | ·4659 | 41 | 40 | ·2916 | 201·4410 | 4 | 238·5590 | ·7084 | 40 |
| 55 | 899·8787 | ·4699 | 40 | 39 | ·2877 | 204·7326 | 55 | 295·2674 | ·7123 | 39 |
| 6 | 62956·3486 | ·4741 | 42 | 40 | ·2837 | 208·0203 | 6 | 351·9797 | ·7163 | 40 |
| 7 | 63012·8227 | ·4782 | 41 | 40 | ·2797 | 211·3040 | 7 | 408·6960 | ·7203 | 40 |
| 8 | 069·3009 | ·4823 | 41 | 39 | ·2758 | 214·5837 | 8 | 465·4163 | ·7242 | 39 |
| 9 | 125·7832 | | 40 | 41 | | 217·8595. | 9 | 522·1405 | | 41 |
| 60 | 63182·2695 | 56·4863 | | | 3·2717 | 160221·1312 | 60 | 66578·8688 | 56·7283 | |

*Mr. Aldis,* LXII. 9.

| | | −63°. | Diff. | Δ². | Δ³. | Diff. | 64°. |
|---|---|---|---|---|---|---|---|
| | | " | " | | | " | 160410·268 |
| | 0 | 66578·8688 | 56·7322 | 39 | 38 | 3·0343 | 413·304 |
| | 1 | 635·6010 | ·7361 | 39 | 39 | ·0304 | 416·334 |
| | 2 | 692·3371 | ·7401 | 40 | 37 | ·0267 | 419·361 |
| | 3 | 749·0772 | ·7440 | 39 | 39 | ·0228 | 422·384 |
| | 4 | 805·8212 | ·7480 | 40 | 38 | ·0190 | 425·403 |
| | 5 | 862·5692 | ·7520 | 40 | 39 | ·0151 | 428·418 |
| | 6 | 919·3212 | ·7559 | 39 | 37 | ·0114 | 431·429 |
| | 7 | 66076·0771 | ·7598 | 39 | 39 | ·0075 | 434·437 |
| | 8 | 67032·8369 | ·7638 | 40 | 37 | 3·0038 | 437·441 |
| | 9 | 089·6007 | ·7677 | 39 | 39 | 2·9999 | |
| | 10 | 146·3684 | ·7717 | 40 | 37 | ·9962 | 440·440 |
| | 11 | 203·1401 | ·7756 | 39 | 39 | ·9923 | 443·436 |
| | 12 | 259·9157 | ·7796 | 40 | 38 | ·9885 | 446·429 |
| | 13 | 316·6953 | ·7834 | 38 | 37 | ·9848 | 449·417 |
| | 14 | 373·4787 | ·7874 | 40 | 39 | ·9809 | 452·402 |
| | 15 | 430·2661 | ·7914 | 40 | 37 | ·9772 | 455·383 |
| | 16 | 487·0575 | ·7952 | 38 | 38 | ·9734 | 458·360 |
| | 17 | 543·8527 | ·7992 | 40 | 39 | ·9695 | 461·334 |
| | 18 | 600·6519 | ·8031 | 39 | 37 | ·9658 | 464·305 |
| | 19 | 657·4550 | ·8070 | 39 | 38 | ·9620 | 467·273 |
| | 20 | 714·2620 | ·8110 | 40 | 37 | ·9583 | 470·238 |
| | 21 | 771·0730 | ·8148 | 38 | 39 | ·9544 | 473·199 |
| | 22 | 827·8878 | ·8188 | 40 | 37 | ·9507 | 476·157 |
| | 23 | 884·7066 | ·8226 | 38 | 38 | ·9469 | 479·094 |
| | 24 | 941·5292 | ·8266 | 40 | 37 | ·9432 | 482·041 |
| | 25 | 67998·3558 | ·8305 | 39 | 39 | ·9393 | 484·984 |
| | 26 | 68055·1863 | ·8344 | 39 | 37 | ·9356 | 487·924 |
| | 27 | 112·0207 | ·8383 | 39 | 37 | ·9319 | 490·859 |
| | 28 | 168·8590 | ·8422 | 39 | 38 | ·9281 | 493·791 |
| | 29 | 225·7012 | ·8461 | 39 | 38 | ·9243 | 496·719 |
| | 30 | 282·5473 | ·8500 | 39 | 38 | ·9205 | 499·644 |
| | 31 | 339·3973 | ·8538 | 38 | 37 | ·9168 | 502·564 |
| | 32 | 396·2511 | ·8578 | 40 | 37 | ·9131 | 505·481 |
| | | 453·1089 | ·8616 | 38 | 38 | ·9093 | 508·394 |

| −64°. | Diff. | Δ². | Δ³. | Diff. | 65°. | ′ | .−65°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 69989·7302 | 56·9657 | 38 | 36 | 2·8090 | 160585·6369 | 0 | 73414·3631 | 57·1910 | 36 |
| 70046·6959 | ·9696 | 39 | 38 | ·8052 | 588·4459 | 1 | 471·5541 | ·1948 | 38 |
| 103·6655 | ·9733 | 37 | 36 | ·8016 | 591·2511 | 2 | 528·7489 | ·1984 | 36 |
| 160·6388 | ·9772 | 39 | 38 | ·7978 | 594·0527 | 3 | 585·9473 | ·2022 | 38 |
| 217·6160 | ·9810 | 38 | 36 | ·7942 | 596·8505 | 4 | 643·1495 | ·2058 | 36 |
| 274·5970 | ·9849 | 39 | 37 | ·7905 | 599·6447 | 5 | 700·3553 | ·2095 | 37 |
| 331·5819 | ·9886 | 37 | 36 | ·7869 | 602·4352 | 6 | 757·5648 | ·2131 | 36 |
| 388·5705 | ·9925 | 39 | 38 | ·7831 | 605·2221 | 7 | 814·7779 | ·2169 | 38 |
| 445·5630 | 56·9962 | 37 | 36 | ·7795 | 608·0052 | 8 | 871·9948 | ·2205 | 36 |
| 502·5592 | 57·0001 | 39 | 36 | ·7759 | 610·7847 | 9 | 929·2153 | ·2241 | 36 |
| 559·5593 | ·0038 | 37 | 37 | ·7722 | 613·5606 | 10 | 73986·4394 | ·2278 | 37 |
| 616·5631 | ·0077 | 39 | 37 | ·7685 | 616·3328 | 1 | 74043·6672 | ·2315 | 37 |
| 673·5708 | ·0115 | 38 | 37 | ·7648 | 619·1013 | 2 | 100·8987 | ·2352 | 37 |
| 730·5823 | ·0152 | 37 | 36 | ·7612 | 621·8661 | 3 | 158·1339 | ·2388 | 36 |
| 787·5975 | ·0191 | 39 | 37 | ·7575 | 624·6273 | 4 | 215·3727 | ·2425 | 37 |
| 844·6166 | ·0228 | 37 | 36 | ·7539 | 627·3848 | 15 | 272·6152 | ·2461 | 36 |
| 901·6394 | ·0266 | 38 | 37 | ·7502 | 630·1387 | 6 | 329·8613 | ·2498 | 37 |
| 70958·6660 | ·0305 | 39 | 36 | ·7466 | 632·8889 | 7 | 387·1111 | ·2534 | 36 |
| 71015·6965 | ·0342 | 37 | 37 | ·7429 | 635·6355 | 8 | 444·3645 | ·2571 | 37 |
| 072·7307 | ·0380 | 38 | 36 | ·7393 | 638·3784 | 9 | 501·6216 | ·2607 | 36 |
| 129·7687 | ·0417 | 37 | 36 | ·7357 | 641·1177 | 20 | 558·8823 | ·2643 | 36 |
| 186·8104 | ·0456 | 39 | 37 | ·7320 | 643·8534 | 1 | 616·1466 | ·2680 | 37 |
| 243·8560 | ·0493 | 37 | 37 | ·7283 | 646·5854 | 2 | 673·4146 | ·2717 | 37 |
| 300·9053 | ·0531 | 38 | 35 | ·7248 | 649·3137 | 3 | 730·6863 | ·2752 | 35 |
| 357·9584 | ·0568 | 37 | 37 | ·7211 | 652·0385 | 4 | 787·9615 | ·2789 | 37 |
| 415·0152 | ·0607 | 39 | 37 | ·7174 | 654·7596 | 25 | 845·2404 | ·2826 | 37 |
| 472·0759 | ·0644 | 37 | 35 | ·7139 | 657·4770 | 6 | 902·5230 | ·2861 | 35 |
| 529·1403 | ·0681 | 37 | 37 | ·7102 | 660·1909 | 7 | 74959·8091 | ·2898 | 37 |
| 586·2084 | ·0719 | 38 | 36 | ·7066 | 662·9011 | 8 | 75017·0989 | ·2934 | 36 |
| 643·2803 | ·0757 | 38 | 36 | ·7030 | 665·6077 | 9 | 074·3923 | ·2970 | 36 |
| 700·3560 | ·0795 | 38 | 37 | ·6993 | 668·3107 | 30 | 131·6893 | ·3007 | 37 |
| 757·4355 | ·0832 | 37 | 35 | ·6958 | 671·0100 | 1 | 188·9900 | ·3042 | 35 |
| 814·5187 | ·0869 | 37 | 37 | ·6921 | 673·7058 | 2 | 246·2942 | ·3079 | 37 |
| 871·6056 | ·0907 | 38 | 36 | ·6885 | 676·3979 | 3 | 303·6021 | ·3115 | 36 |
| 928·6963 | ·0944 | 37 | 36 | ·6849 | 679·0864 | 4 | 360·9136 | ·3151 | 36 |
| 71985·7907 | ·0982 | 38 | 36 | ·6813 | 681·7713 | 35 | 418·2287 | ·3187 | 36 |
| 72042·8889 | ·1019 | 37 | 36 | ·6777 | 684·4526 | 6 | 475·5474 | ·3223 | 36 |
| 099·9908 | ·1057 | 38 | 36 | ·6741 | 687·1303 | 7 | 532·8697 | ·3259 | 36 |
| 157·0965 | ·1094 | 37 | 36 | ·6705 | 689·8044 | 8 | 590·1956 | ·3295 | 36 |
| 214·2059 | ·1132 | 38 | 37 | ·6668 | 692·4749 | 9 | 647·5251 | ·3332 | 37 |
| 271·3191 | ·1168 | 36 | 35 | ·6633 | 695·1417 | 40 | 704·8583 | ·3367 | 35 |
| 328·4359 | ·1206 | 38 | 36 | ·6597 | 697·8050 | 1 | 762·1950 | ·3403 | 36 |
| 385·5565 | ·1244 | 38 | 36 | ·6561 | 700·4647 | 2 | 819·5353 | ·3439 | 36 |
| 442·6809 | ·1281 | 37 | 36 | ·6525 | 703·1208 | 3 | 876·8792 | ·3475 | 36 |
| 499·8090 | ·1318 | 37 | 35 | ·6490 | 705·7733 | 4 | 934·2267 | ·3510 | 35 |
| 556·9408 | ·1355 | 37 | 37 | ·6453 | 708·4223 | 45 | 75991·5777 | ·3547 | 37 |
| 614·0763 | ·1392 | 37 | 35 | ·6418 | 711·0676 | 6 | 76048·9324 | ·3582 | 35 |
| 671·2155 | ·1430 | 38 | 36 | ·6382 | 713·7094 | 7 | 106·2906 | ·3618 | 36 |
| 728·3585 | ·1466 | 36 | 36 | ·6346 | 716·3476 | 8 | 163·6524 | ·3654 | 36 |
| 785·5051 | ·1504 | 38 | 36 | ·6310 | 718·9822 | 9 | 221·0178 | ·3690 | 36 |
| 842·6555 | ·1541 | 37 | 35 | ·6275 | 721·6132 | 50 | 278·3868 | ·3725 | 35 |
| 899·8096 | ·1578 | 37 | 36 | ·6239 | 724·2407 | 1 | 335·7593 | ·3761 | 36 |
| 72956·9674 | ·1615 | 37 | 36 | ·6203 | 726·8646 | 2 | 393·1354 | ·3797 | 36 |
| 73014·1289 | ·1652 | 37 | 36 | ·6167 | 729·4849 | 3 | 450·5151 | ·3833 | 36 |
| 071·2941 | ·1689 | 37 | 35 | ·6132 | 732·1016 | 4 | 507·8984 | ·3868 | 35 |
| 128·4630 | ·1727 | 38 | 35 | ·6097 | 734·7148 | 55 | 565·2852 | ·3903 | 35 |
| 185·6357 | ·1763 | 36 | 36 | ·6061 | 737·3245 | 6 | 622·6755 | ·3939 | 36 |
| 242·8120 | ·1800 | 37 | 36 | ·6025 | 739·9306 | 7 | 680·0694 | ·3975 | 36 |
| 299·9920 | ·1837 | 37 | 36 | ·5989 | 742·5331 | 8 | 737·4669 | ·4011 | 36 |
| 357·1757 | 57·1874 | 37 | 35 | 2·5954 | 745·1320 | 9 | 794·8680 | 57·4046 | 35 |
| 73414·3631 | | | | | 160747·7274 | 60 | 76852·2726 | | |



| | | | | |
|---|---|---|---|---|
| | ·5505 | 776·0432 | 1 | |
| 35 | ·5530 | 778·5962 | 2 | |
| 36 | ·5494 | 781·1456 | 3 | |
| 34 | ·5460 | 783·6916 | 4 | |
| 36 | ·5424 | 786·2340 | 15 | |
| 35 | ·5389 | 788·7729 | 6 | |
| 35 | ·5354 | 791·3083 | 7 | |
| 36 | ·5318 | 793·8401 | 8 | |
| 34 | ·5284 | 796·3685 | 9 | |
| 35 | ·5249 | | | |
| 36 | | 798·8934 | 20 | |
| 34 | ·5213 | 801·4147 | 1 | |
| 36 | ·5179 | 803·9326 | 2 | |
| 34 | ·5143 | 806·4469 | 3 | |
| 35 | ·5109 | 808·9578 | 4 | |
| 35 | ·5074 | 811·4652 | 25 | |
| 35 | ·5039 | 813·9691 | 6 | |
| 35 | ·5004 | 816·4695 | 7 | |
| 35 | ·4969 | 818·9664 | 8 | |
| 35 | ·4934 | 821·4598 | 9 | |
| 35 | ·4899 | | | |
| 34 | ·4865 | 823·9497 | 30 | |
| 35 | ·4830 | 826·4362 | 1 | |
| 35 | ·4795 | 828·9192 | 2 | |
| 35 | ·4760 | 831·3987 | 3 | |
| 34 | ·4726 | 833·8747 | 4 | |
| 35 | ·4691 | 836·3473 | 35 | |
| 35 | ·4656 | 838·8164 | 6 | |
| 35 | ·4621 | 841·2820 | 7 | 7 |
| 34 | ·4587 | 843·7441 | 8 | 7 |
| 34 | ·4553 | 846·2028 | 9 | |
| 35 | ·4518 | 848·6581 | 40 | |
| 35 | ·4483 | 851·1099 | 1 | |
| 34 | ·4449 | 853·5582 | 2 | |
| 35 | ·4414 | 856·0031 | 3 | |
| 34 | ·4380 | 858·4445 | 4 | |
| 34 | ·4346 | 860·8825 | 45 | |
| 35 | ·4311 | 863·3171 | 6 | |
| 35 | ·4276 | 865·7482 | 7 | |
| 34 | ·4242 | 868·1758 | 8 | |
| 34 | | | | |



68



| −67°. | Diff. | Δ². | Δ². | Diff. | 68°. | ′ | −68°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 80302·9597 | 57·6169 | 35 | 32 | 2·1829 | 161034·0782 | 0 | 83765·9218 | 57·8171 | 32 |
| 360·5766 | ·6202 | 33 | 34 | ·1795 | 036·2611 | 1 | 823·7389 | ·8205 | 34 |
| 418·1968 | ·6237 | 35 | 32 | ·1763 | 038·4406 | 2 | 881·5594 | ·8237 | 32 |
| 475·8205 | ·6271 | 34 | 32 | ·1731 | 040·6169 | 3 | 939·3831 | ·8269 | 32 |
| 533·4476 | ·6305 | 34 | 33 | ·1698 | 042·7900 | 4 | 83997·2100 | ·8302 | 33 |
| 591·0781 | ·6338 | 33 | 33 | ·1665 | 044·9598 | 5 | 84055·0402 | ·8335 | 33 |
| 648·7119 | ·6373 | 35 | 32 | ·1633 | 047·1263 | 6 | 112·8737 | ·8367 | 32 |
| 706·3492 | ·6406 | 33 | 32 | ·1601 | 049·2896 | 7 | 170·7104 | ·8399 | 32 |
| 763·9898 | ·6441 | 35 | 33 | ·1568 | 051·4497 | 8 | 228·5503 | ·8432 | 33 |
| 821·6339 | ·6474 | 33 | 33 | ·1535 | 053·6065 | 9 | 286·3935 | ·8465 | 33 |
| 879·2813 | ·6508 | 34 | 32 | ·1503 | 055·7600 | 10 | 344·2400 | ·8497 | 32 |
| 936·9321 | ·6542 | 34 | 33 | ·1470 | 057·9103 | 1 | 402·0897 | ·8530 | 33 |
| 80994·5863 | ·6576 | 34 | 32 | ·1438 | 060·0573 | 2 | 459·9427 | ·8562 | 32 |
| 81052·2439 | ·6610 | 34 | 32 | ·1406 | 062·2011 | 3 | 517·7989 | ·8594 | 32 |
| 109·9049 | ·6643 | 33 | 33 | ·1373 | 064·3417 | 4 | 575·6583 | ·8627 | 33 |
| 167·5692 | ·6677 | 34 | 32 | ·1341 | 066·4790 | 15 | 633·5210 | ·8659 | 32 |
| 225·2369 | ·6711 | 34 | 32 | ·1309 | 068·6131 | 6 | 691·3869 | ·8691 | 32 |
| 282·9080 | ·6745 | 34 | 33 | ·1276 | 070·7440 | 7 | 749·2560 | ·8724 | 33 |
| 340·5825 | ·6778 | 33 | 32 | ·1244 | 072·8716 | 8 | 807·1284 | ·8756 | 32 |
| 398·2603 | ·6812 | 34 | 32 | ·1212 | 074·9960 | 9 | 865·0040 | ·8788 | 32 |
| 455·9415 | ·6845 | 33 | 32 | ·1180 | 077·1172 | 20 | 922·8828 | ·8820 | 32 |
| 513·6260 | ·6880 | 35 | 33 | ·1147 | 079·2352 | 1 | 84980·7648 | ·8853 | 33 |
| 571·3140 | ·6912 | 32 | 31 | ·1116 | 081·3499 | 2 | 85038·6501 | ·8884 | 31 |
| 629·0052 | ·6947 | 35 | 33 | ·1083 | 083·4615 | 3 | 096·5385 | ·8917 | 33 |
| 686·6999 | ·6980 | 33 | 32 | ·1051 | 085·5698 | 4 | 154·4302 | ·8949 | 32 |
| 744·3979 | ·7013 | 33 | 33 | ·1018 | 087·6749 | 25 | 212·3251 | ·8982 | 33 |
| 802·0992 | ·7047 | 34 | 31 | ·0987 | 089·7767 | 6 | 270·2233 | ·9013 | 31 |
| 859·8039 | ·7080 | 33 | 32 | ·0955 | 091·8754 | 7 | 328·1246 | ·9045 | 32 |
| 917·5119 | ·7114 | 34 | 32 | ·0923 | 093·9709 | 8 | 386·0291 | ·9077 | 32 |
| 81975·2233 | ·7147 | 33 | 33 | ·0890 | 096·0632 | 9 | 443·9368 | ·9110 | 33 |
| 82032·9380 | ·7180 | 33 | 31 | ·0859 | 098·1522 | 30 | 501·8478 | ·9141 | 31 |
| 090·6560 | ·7214 | 34 | 32 | ·0827 | 100·2381 | 1 | 559·7619 | ·9173 | 32 |
| 148·3774 | ·7248 | 34 | 32 | ·0795 | 102·3208 | 2 | 617·6792 | ·9205 | 32 |
| 206·1022 | ·7280 | 32 | 32 | ·0763 | 104·4003 | 3 | 675·5997 | ·9237 | 32 |
| 263·8302 | ·7314 | 34 | 32 | ·0731 | 106·4766 | 4 | 733·5234 | ·9269 | 32 |
| 321·5616 | ·7347 | 33 | 32 | ·0699 | 108·5497 | 35 | 791·4503 | ·9301 | 32 |
| 379·2963 | ·7381 | 34 | 32 | ·0667 | 110·6196 | 6 | 849·3804 | ·9333 | 32 |
| 437·0344 | ·7414 | 33 | 31 | ·0636 | 112·6863 | 7 | 907·3137 | ·9364 | 31 |
| 494·7758 | ·7446 | 32 | 32 | ·0604 | 114·7499 | 8 | 85965·2501 | ·9396 | 32 |
| 552·5204 | ·7480 | 34 | 32 | ·0572 | 116·8103 | 9 | 86023·1897 | ·9428 | 32 |
| 610·2684 | ·7514 | 34 | 32 | ·0540 | 118·8675 | 40 | 081·1325 | ·9460 | 32 |
| 668·0198 | ·7546 | 32 | 32 | ·0508 | 120·9215 | 1 | 139·0785 | ·9492 | 32 |
| 725·7744 | ·7579 | 33 | 31 | ·0477 | 122·9723 | 2 | 197·0277 | ·9523 | 31 |
| 783·5323 | ·7613 | 34 | 32 | ·0445 | 125·0200 | 3 | 254·9800 | ·9555 | 32 |
| 841·2936 | ·7646 | 33 | 31 | ·0414 | 127·0645 | 4 | 312·9355 | ·9586 | 31 |
| 899·0582 | ·7678 | 32 | 32 | ·0382 | 129·1059 | 45 | 370·8941 | ·9618 | 32 |
| 82956·8260 | ·7712 | 34 | 32 | ·0350 | 131·1441 | 6 | 428·8559 | ·9650 | 32 |
| 83014·5972 | ·7745 | 33 | 32 | ·0318 | 133·1791 | 7 | 486·8209 | ·9682 | 32 |
| 072·3717 | ·7777 | 32 | 31 | ·0287 | 135·2109 | 8 | 544·7891 | ·9713 | 31 |
| 130·1494 | ·7811 | 34 | 31 | ·0256 | 137·2396 | 9 | 602·7604 | ·9744 | 31 |
| 187·9305 | ·7843 | 32 | 32 | ·0224 | 139·2652 | 50 | 660·7348 | ·9776 | 32 |
| 245·7148 | ·7877 | 34 | 31 | ·0193 | 141·2876 | 1 | 718·7124 | ·9807 | 31 |
| 303·5025 | ·7909 | 32 | 32 | ·0161 | 143·3069 | 2 | 776·6931 | ·9839 | 32 |
| 361·2934 | ·7942 | 33 | 32 | ·0129 | 145·3230 | 3 | 834·6770 | ·9871 | 32 |
| 419·0876 | ·7975 | 33 | 30 | ·0099 | 147·3359 | 4 | 892·6641 | ·9901 | 30 |
| 476·8851 | ·8008 | 33 | 32 | ·0067 | 149·3458 | 55 | 86950·6542 | ·9933 | 32 |
| 534·6859 | ·8041 | 33 | 32 | ·0035 | 151·3525 | 6 | 87008·6475 | ·9965 | 32 |
| 592·4900 | ·8073 | 32 | 31 | 2·0004 | 153·3560 | 7 | 066·6440 | 57·9996 | 31 |
| 650·2973 | ·8106 | 33 | 31 | 1·9973 | 155·3564 | 8 | 124·6436 | 58·0027 | 31 |
| 708·1079 | 57·8139 | 33 | 32 | 1·9941 | 157·3537 | 9 | 182·6463 | 58·0059 | 32 |
| 83765·9218 | | | | | 161159·3478 | 60 | 87240·6522 | | |

| 69°. | | −69°. | Diff. | Δ¹. | Δ². | Diff. | |
|---|---|---|---|---|---|---|---|
| | | | " | | | " | |
| 61159·3478 | 0 | 87240·6522 | 58·0089 | 30 | 30 | 1·8077 | 1612 |
| 161·3389 | 1 | 298·6611 | ·0121 | 32 | 29 | ·8048 | 1 |
| 163·3268 | 2 | 356·6732 | ·0153 | 32 | 31 | ·8017 | 1 |
| 165·3115 | 3 | 414·6885 | ·0183 | 30 | 29 | ·7988 | 1 |
| 167·2932 | 4 | 472·7068 | ·0215 | 32 | 30 | ·7958 | 1 |
| 169·2717 | 5 | 530·7283 | ·0246 | 31 | 29 | ·7929 | 1 |
| 171·2471 | 6 | 588·7529 | ·0276 | 30 | 30 | ·7899 | 1 |
| 173·2195 | 7 | 646·7805 | ·0308 | 32 | 30 | ·7869 | 1 |
| 175·1887 | 8 | 704·8113 | ·0339 | 31 | 30 | ·7839 | 1 |
| 177·1548 | 9 | 762·8452 | ·0371 | 32 | 29 | ·7810 | 1 |
| 179·1177 | 10 | 820·8823 | ·0401 | 30 | 30 | ·7780 | 1 |
| 181·0776 | 1 | 878·9224 | ·0432 | 31 | 30 | ·7750 | 1 |
| 183·0344 | 2 | 936·9656 | ·0463 | 31 | 29 | ·7721 | 1 |
| 184·9881 | 3 | 87995·0119 | ·0494 | 31 | 29 | ·7692 | 1 |
| 186·9387 | 4 | 88053·0613 | ·0525 | 31 | 30 | ·7662 | 1 |
| 188·8862 | 15 | 111·1138 | ·0556 | 31 | 30 | ·7632 | 1 |
| 190·8306 | 6 | 169·1694 | ·0587 | 31 | 29 | ·7603 | 1 |
| 192·7719 | 7 | 227·2281 | ·0618 | 31 | 29 | ·7574 | 1 |
| 194·7101 | 8 | 285·2899 | ·0649 | 31 | 30 | ·7544 | 1 |
| 196·6452 | 9 | 343·3548 | ·0680 | 31 | 29 | ·7515 | 1 |
| 198·5772 | 20 | 401·4228 | ·0710 | 30 | 30 | ·7485 | 1 |
| 200·5062 | 1 | 459·4938 | ·0741 | 31 | 29 | ·7456 | 1 |
| 202·4321 | 2 | 517·5679 | ·0771 | 30 | 29 | ·7427 | 1 |
| 204·3550 | 3 | 575·6450 | ·0803 | 32 | 30 | ·7397 | 1 |
| 206·2747 | 4 | 633·7253 | ·0833 | 30 | 29 | ·7368 | 1 |
| 208·1914 | 25 | 691·8086 | ·0864 | 31 | 29 | ·7339 | 1 |
| 210·1050 | 6 | 749·8950 | ·0894 | 30 | 29 | ·7310 | 1 |
| 212·0156 | 7 | 807·9844 | ·0926 | 32 | 30 | ·7280 | 1 |
| 213·9230 | 8 | 866·0770 | ·0955 | 29 | 29 | ·7251 | 1 |
| 215·8275 | 9 | 924·1725 | ·0987 | 32 | 28 | ·7223 | 1 |
| 217·7288 | 30 | 88982·2712 | ·1017 | 30 | 30 | ·7193 | 1 |
| 219·6271 | 1 | 89040·3729 | ·1047 | 30 | 29 | ·7164 | 1 |
| 221·5224 | 2 | 098·4776 | ·1078 | 31 | 30 | ·7134 | 1 |

| −70°. | Diff. | Δ². | Δ³. | Diff. | 71°. | ′ | −71°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 90726·6407 | | 30 | 29 | | 161376·6262 | 0 | 94223·3738 | | 29 |
| 784·8330 | 58·1923 | 29 | 29 | 1·6330 | 378·2592 | 1 | 281·7408 | 58·3670 | 29 |
| 843·0282 | ·1952 | 31 | 27 | ·6301 | 379·8893 | 2 | 340·1107 | ·3699 | 27 |
| 901·2265 | ·1983 | 29 | 29 | ·6274 | 381·5167 | 3 | 398·4833 | ·3726 | 29 |
| 90959·4277 | ·2012 | 30 | 28 | ·6245 | 383·1412 | 4 | 456·8588 | ·3755 | 28 |
| 91017·6319 | ·2042 | 29 | 29 | ·6217 | 384·7629 | 5 | 515·2371 | ·3783 | 29 |
| 075·8390 | ·2071 | 30 | 27 | ·6188 | 386·3817 | 6 | 573·6183 | ·3812 | 27 |
| 134·0491 | ·2101 | 30 | 29 | ·6161 | 387·9978 | 7 | 632·0022 | ·3839 | 29 |
| 192·2622 | ·2131 | 30 | 28 | ·6132 | 389·6110 | 8 | 690·3890 | ·3868 | 28 |
| 250·4783 | ·2161 | 29 | 29 | ·6104 | 391·2214 | 9 | 748·7786 | ·3896 | 29 |
| | ·2190 | | | ·6075 | | | | ·3925 | |
| 308·6973 | ·2220 | 30 | 27 | ·6048 | 392·8289 | 10 | 807·1711 | ·3952 | 27 |
| 366·9193 | ·2250 | 30 | 29 | ·6019 | 394·4337 | 1 | 865·5663 | ·3981 | 29 |
| 425·1443 | ·2279 | 29 | 28 | ·5991 | 396·0356 | 2 | 923·9644 | ·4009 | 28 |
| 483·3722 | ·2308 | 29 | 28 | ·5963 | 397·6347 | 3 | 94982·3653 | ·4037 | 28 |
| 541·6030 | ·2338 | 30 | 28 | ·5935 | 399·2310 | 4 | 95040·7690 | ·4065 | 28 |
| 599·8368 | ·2368 | 30 | 28 | ·5907 | 400·8245 | 15 | 099·1755 | ·4093 | 28 |
| 658·0736 | ·2397 | 29 | 28 | ·5879 | 402·4152 | 6 | 157·5848 | ·4121 | 28 |
| 716·3133 | ·2426 | 29 | 28 | ·5851 | 404·0031 | 7 | 215·9969 | ·4149 | 28 |
| 774·5559 | ·2456 | 30 | 28 | ·5823 | 405·5882 | 8 | 274·4118 | ·4177 | 28 |
| 832·8015 | ·2485 | 29 | 28 | ·5795 | 407·1705 | 9 | 332·8295 | ·4205 | 28 |
| 891·0500 | ·2515 | 30 | 28 | ·5767 | 408·7500 | 20 | 391·2500 | ·4233 | 28 |
| 91949·3015 | ·2544 | 29 | 28 | ·5739 | 410·3267 | 1 | 449·6733 | ·4261 | 28 |
| 92007·5559 | ·2573 | 29 | 28 | ·5711 | 411·9006 | 2 | 508·0994 | ·4289 | 28 |
| 065·8132 | ·2603 | 30 | 27 | ·5684 | 413·4717 | 3 | 566·5283 | ·4316 | 27 |
| 124·0735 | ·2632 | 29 | 29 | ·5655 | 415·0401 | 4 | 624·9599 | ·4345 | 29 |
| 182·3367 | ·2661 | 29 | 27 | ·5628 | 416·6056 | 25 | 683·3944 | ·4372 | 27 |
| 240·6028 | ·2690 | 29 | 28 | ·5600 | 418·1684 | 6 | 741·8316 | ·4400 | 28 |
| 298·8718 | ·2720 | 30 | 28 | ·5572 | 419·7284 | 7 | 800·2716 | ·4428 | 28 |
| 357·1438 | ·2749 | 29 | 27 | ·5545 | 421·2856 | 8 | 858·7144 | ·4455 | 27 |
| 415·4187 | ·2777 | 28 | 29 | ·5516 | 422·8401 | 9 | 917·1599 | ·4484 | 29 |
| 473·6964 | ·2807 | 30 | 27 | ·5489 | 424·3917 | 30 | 95975·6083 | ·4511 | 27 |
| 531·9771 | ·2836 | 29 | 27 | ·5462 | 425·9406 | 1 | 96034·0594 | ·4538 | 27 |
| 590·2607 | ·2866 | 30 | 28 | ·5434 | 427·4868 | 2 | 092·5132 | ·4566 | 28 |
| 648·5473 | ·2894 | 28 | 28 | ·5406 | 429·0302 | 3 | 150·9698 | ·4594 | 28 |
| 706·8367 | ·2923 | 29 | 28 | ·5378 | 430·5708 | 4 | 209·4292 | ·4622 | 28 |
| 765·1290 | ·2952 | 29 | 27 | ·5351 | 432·1086 | 35 | 267·8914 | ·4649 | 27 |
| 823·4242 | ·2982 | 30 | 27 | ·5324 | 433·6437 | 6 | 326·3563 | ·4676 | 27 |
| 881·7224 | ·3010 | 28 | 28 | ·5296 | 435·1761 | 7 | 384·8239 | ·4704 | 28 |
| 940·0234 | ·3039 | 29 | 28 | ·5268 | 436·7057 | 8 | 443·2943 | ·4732 | 28 |
| 92998·3273 | ·3068 | 29 | 27 | ·5241 | 438·2325 | 9 | 501·7675 | ·4759 | 27 |
| 93056·6341 | ·3097 | 29 | 27 | ·5214 | 439·7566 | 40 | 560·2434 | ·4786 | 27 |
| 114·9438 | ·3126 | 29 | 28 | ·5186 | 441·2780 | 1 | 618·7220 | ·4814 | 28 |
| 173·2564 | ·3155 | 29 | 28 | ·5158 | 442·7966 | 2 | 677·2034 | ·4842 | 28 |
| 231·5719 | ·3183 | 28 | 27 | ·5131 | 444·3124 | 3 | 735·6876 | ·4869 | 27 |
| 289·8902 | ·3213 | 30 | 27 | ·5104 | 445·8255 | 4 | 794·1745 | ·4896 | 27 |
| 348·2115 | ·3241 | 28 | 27 | ·5077 | 447·3359 | 45 | 852·6641 | ·4923 | 27 |
| 406·5356 | ·3270 | 29 | 28 | ·5049 | 448·8436 | 6 | 911·1564 | ·4951 | 28 |
| 464·8626 | ·3298 | 28 | 27 | ·5022 | 450·3485 | 7 | 96969·6515 | ·4978 | 27 |
| 523·1924 | ·3327 | 29 | 27 | ·4995 | 451·8507 | 8 | 97028·1493 | ·5005 | 27 |
| 581·5251 | ·3356 | 29 | 27 | ·4968 | 453·3502 | 9 | 086·6498 | ·5032 | 27 |
| 639·8607 | ·3385 | 29 | 28 | ·4940 | 454·8470 | 50 | 145·1530 | ·5060 | 28 |
| 698·1992 | ·3413 | 28 | 27 | ·4913 | 456·3410 | 1 | 203·6590 | ·5087 | 27 |
| 756·5405 | ·3442 | 29 | 27 | ·4886 | 457·8323 | 2 | 262·1677 | ·5114 | 27 |
| 814·8847 | ·3470 | 28 | 27 | ·4859 | 459·3209 | 3 | 320·6791 | ·5141 | 27 |
| 873·2317 | ·3499 | 29 | 27 | ·4832 | 460·8068 | 4 | 379·1932 | ·5168 | 27 |
| 931·5816 | ·3528 | 29 | 28 | ·4804 | 462·2900 | 55 | 437·7100 | ·5196 | 28 |
| 93989·9344 | ·3556 | 28 | 26 | ·4778 | 463·7704 | 6 | 496·2296 | ·5222 | 26 |
| 94048·2900 | ·3584 | 28 | 28 | ·4750 | 465·2482 | 7 | 554·7518 | ·5250 | 28 |
| 106·6484 | ·3613 | 29 | 26 | ·4724 | 466·7232 | 8 | 613·2768 | ·5276 | 26 |
| 165·0097 | ·3641 | 28 | 28 | ·4696 | 468·1956 | 9 | 671·8044 | ·5304 | 28 |
| 94223·3738 | 58·3641 | | | 1·4696 | 161469·6652 | 60 | 97730·3348 | 58·5304 | |

| | | | |
|---|---|---|---|
| 27 | .4401 | 484.2139 | |
| 27 | .4374 | 485.6540 | |
| 26 | .4348 | 487.0914 | |
| 27 | .4321 | 488.5262 | |
| 26 | .4295 | 489.9583 | |
| 27 | .4268 | 491.3878 | |
| 27 | .4241 | 492.8146 | |
| 26 | .4215 | 494.2387 | |
| 27 | .4188 | 495.6602 | |
| 26 | .4162 | 497.0790 | |
| 27 | .4135 | 498.4952 | 2 |
| 26 | .4109 | 499.9087 | |
| 26 | .4083 | 501.3196 | |
| 27 | .4056 | 502.7279 | |
| 27 | .4029 | 504.1335 | |
| 26 | .4003 | 505.5364 | 2 |
| 26 | .3977 | 506.9367 | 6 |
| 26 | .3951 | 508.3344 | 7 |
| 27 | .3924 | 509.7295 | 8 |
| 26 | .3898 | 511.1219 | 9 |
| 26 | .3872 | 512.5117 | 30 |
| 26 | .3846 | 513.8989 | 1 |
| 27 | .3819 | 515.2835 | 2 |
| 26 | .3793 | 516.6654 | 3 |
| 26 | .3767 | 518.0447 | 4 |
| 26 | .3741 | 519.4214 | 35 |
| 26 | .3715 | 520.7955 | 6 |
| 26 | .3689 | 522.1670 | 7 |
| 26 | .3663 | 523.5359 | 8 |
| 27 | .3636 | 524.9022 | 9 |
| 25 | .3611 | 526.2658 | 40 |
| 26 | .3585 | 527.6269 | 1 |
| 26 | .3559 | 528.9854 | 2 |
| 26 | .3533 | 530.3413 | 3 |
| 26 | .3507 | 531.6946 | 4 |
| 26 | .3481 | 533.0453 | 45 |
| 26 | .3455 | 534.3934 | 6 |
| 26 | .3429 | 535.7389 | 7 |
| 25 | .3401 | 537.0818 | 8 |



74



| −73°. | Diff. | Δ². | Δ². | Diff. | 74°. | , | −74°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| " | " | | | " | " | | " | | |
| 101247·0035. | 58·6904 | 25 | 25 | 1·1609 | 161627·1429 | 0 | 104772·8571 | 58·8391 | 25 |
| 305·6939 | ·6930 | 26 | 23 | ·1586 | 628·3038 | 1 | 831·6962 | ·8414 | 23 |
| 364·3869 | ·6955 | 25 | 25 | ·1561 | 629·4624 | 2 | 890·5376 | ·8439 | 25 |
| 423·0824 | ·6980 | 25 | 23 | ·1538 | 630·6185 | 3 | 104949·3815. | ·8462 | 23 |
| 481·7804 | ·7006 | 26 | 25 | ·1513 | 631·7723 | 4 | 105008·2277 | ·8487 | 25 |
| 540·4810 | ·7032 | 26 | 23 | ·1490 | 632·9236 | 5 | 067·0764 | ·8510 | 23 |
| 599·1842 | ·7057 | 25 | 25 | ·1465 | 634·0726 | 6 | 125·9274 | ·8535 | 25 |
| 657·8899 | ·7082 | 25 | 23 | ·1442 | 635·2191 | 7 | 184·7809 | ·8558 | 23 |
| 716·5981 | ·7107 | 25 | 24 | ·1418 | 636·3633 | 8 | 243·6367 | ·8582 | 24 |
| 775·3088 | ·7133 | 26 | 24 | ·1394 | 637·5051 | 9 | 302·4949 | ·8606 | 24 |
| 834·0221 | ·7158 | 25 | 23 | ·1371 | 638·6445. | 10 | 361·3555 | ·8629 | 23 |
| 892·7379 | ·7183 | 25 | 25 | ·1346 | 639·7816 | 1 | 420·2184 | ·8654 | 25 |
| 101951·4562 | ·7208 | 25 | 23 | ·1323 | 640·9162 | 2 | 479·0838 | ·8677 | 23 |
| 102010·1770 | ·7234 | 26 | 24 | ·1299 | 642·0485. | 3 | 537·9515 | ·8701 | 24 |
| 068·9004 | ·7259 | 25 | 24 | ·1275 | 643·1784 | 4 | 596·8216 | ·8725 | 24 |
| 127·6263 | ·7284 | 25 | 23 | ·1252 | 644·3059 | 15 | 655·6941 | ·8748 | 23 |
| 186·3547 | ·7309 | 25 | 24 | ·1228 | 645·4311 | 6 | 714·5689 | ·8772 | 24 |
| 245·0856 | ·7334 | 25 | 24 | ·1204 | 646·5539 | 7 | 773·4461 | ·8796 | 24 |
| 303·8190 | ·7360 | 26 | 23 | ·1181 | 647·6743 | 8 | 832·3257 | ·8819 | 23 |
| 362·5550. | ·7384 | 24 | 24 | ·1157 | 648·7924 | 9 | 891·2076 | ·8843 | 24 |
| 421·2934 | ·7409 | 25 | 24 | ·1133 | 649·9081 | 20 | 105950·0919 | ·8867 | 24 |
| 480·0343 | ·7435 | 26 | 23 | ·1110 | 651·0214 | 1 | 106008·9786 | ·8890 | 23 |
| 538·7778 | ·7459 | 24 | 23 | ·1087 | 652·1324 | 2 | 067·8676 | ·8913 | 23 |
| 597·5237 | ·7484 | 25 | 25 | ·1062 | 653·2411 | 3 | 126·7589 | ·8938 | 25 |
| 656·2721 | ·7509 | 25 | 22 | ·1040 | 654·3473 | 4 | 185·6527 | ·8960 | 22 |
| 715·0230 | ·7535 | 26 | 24 | ·1016 | 655·4513 | 25 | 244·5487 | ·8984 | 24 |
| 773·7765. | ·7559 | 24 | 23 | ·0993 | 656·5529 | 6 | 303·4471 | ·9007 | 23 |
| 832·5324 | ·7583 | 24 | 24 | ·0969 | 657·6522 | 7 | 362·3478 | ·9031 | 24 |
| 891·2907 | ·7609 | 26 | 23 | ·0946 | 658·7491 | 8 | 421·2509 | ·9054 | 23 |
| 102950·0516 | ·7634 | 25 | 24 | ·0922 | 659·8437 | 9 | 480·1563 | ·9078 | 24 |
| 103008·8150. | ·7658 | 24 | 23 | ·0899 | 660·9359 | 30 | 539·0641 | ·9101 | 23 |
| 067·5808 | ·7683 | 25 | 23 | ·0876 | 662·0258 | 1 | 597·9742 | ·9124 | 23 |
| 126·3491 | ·7708 | 25 | 23 | ·0853 | 663·1134 | 2 | 656·8866 | ·9147 | 23 |
| 185·1199 | ·7732 | 24 | 23 | ·0830 | 664·1987 | 3 | 715·8013 | ·9170 | 23 |
| 243·8931 | ·7758 | 26 | 24 | ·0806 | 665·2817 | 4 | 774·7183 | ·9194 | 24 |
| 302·6689 | ·7782 | 24 | 23 | ·0783 | 666·3623 | 35 | 833·6377 | ·9217 | 23 |
| 361·4471 | ·7806 | 24 | 24 | ·0759 | 667·4406 | 6 | 892·5594 | ·9241 | 24 |
| 420·2277 | ·7831 | 25 | 22 | ·0737 | 668·5165 | 7 | 106951·4835. | ·9263 | 22 |
| 479·0108 | ·7856 | 25 | 23 | ·0714 | 669·5902 | 8 | 107010·4098 | ·9286 | 23 |
| 537·7964 | ·7880 | 24 | 24 | ·0690 | 670·6616 | 9 | 069·3384 | ·9310 | 24 |
| 596·5844 | ·7905 | 25 | 23 | ·0667 | 671·7306 | 40 | 128·2694 | ·9333 | 23 |
| 655·3749 | ·7929 | 24 | 22 | ·0645 | 672·7973 | 1 | 187·2027 | ·9355 | 22 |
| 714·1678 | ·7954 | 25 | 24 | ·0621 | 673·8618 | 2 | 246·1382 | ·9379 | 24 |
| 772·9632 | ·7978 | 24 | 23 | ·0598 | 674·9239 | 3 | 305·0761 | ·9402 | 23 |
| 831·7610 | ·8003 | 25 | 23 | ·0575 | 675·9837 | 4 | 364·0163 | ·9425 | 23 |
| 890·5613 | ·8027 | 24 | 22 | ·0553 | 677·0412 | 45 | 422·9588 | ·9447 | 22 |
| 103949·3640 | ·8052 | 25 | 24 | ·0529 | 678·0965. | 6 | 481·9035 | ·9471 | 24 |
| 104008·1692 | ·8076 | 24 | 22 | ·0507 | 679·1494 | 7 | 540·8506 | ·9493 | 22 |
| 066·9768 | ·8100 | 24 | 24 | ·0483 | 680·2001 | 8 | 599·7999 | ·9517 | 24 |
| 125·7868 | ·8125 | 25 | 22 | ·0461 | 681·2484 | 9 | 658·7516 | ·9539 | 22 |
| 184·5993 | ·8149 | 24 | 23 | ·0438 | 682·2945 | 50 | 717·7055. | ·9562 | 23 |
| 243·4142 | ·8173 | 24 | 23 | ·0415 | 683·3383 | 1 | 776·6617 | ·9585 | 23 |
| 302·2315. | ·8197 | 24 | 23 | ·0392 | 684·3798 | 2 | 835·6202 | ·9608 | 23 |
| 361·0512 | ·8222 | 25 | 22 | ·0370 | 685·4190 | 3 | 894·5810 | ·9630 | 22 |
| 419·8734 | ·8246 | 24 | 23 | ·0347 | 686·4560 | 4 | 107953·5440 | ·9653 | 23 |
| 478·6980 | ·8270 | 24 | 23 | ·0324 | 687·4907 | 55 | 108012·5093 | ·9676 | 23 |
| 537·5250. | ·8294 | 24 | 23 | ·0301 | 688·5231 | 6 | 071·4769 | ·9699 | 23 |
| 596·3544 | ·8318 | 24 | 22 | ·0279 | 689·5532 | 7 | 130·4468 | ·9721 | 22 |
| 655·1862 | ·8343 | 25 | 23 | ·0256 | 690·5811 | 8 | 189·4189 | ·9744 | 23 |
| 714·0205. | 58·8366 | 23 | 22 | 1·0234 | 691·6067 | 9 | 248·3933 | 58·9766 | 22 |
| 104772·8571 | | | | | 161692·6301 | 60 | 108307·3699 | | |

75



| 75°. | ′ | −75°. | Diff. | Δ¹. | Δ². | Diff. | 76°. |
|---|---|---|---|---|---|---|---|
| ″ | | ″ | ″ | | | ″ | ″ |
| 1692·6301 | 0 | 108307·3699 | 58·9789 | 23 | 22 | 0·8900 | 161749 |
| 693·6512 | 1 | 366·3488 | ·9812 | 23 | 20 | ·8880 | 750 |
| 694·6700 | 2 | 425·3300 | ·9834 | 22 | 21 | ·8859 | 751 |
| 695·6866 | 3 | 484·3134 | ·9857 | 23 | 22 | ·8837 | 752 |
| 696·7009 | 4 | 543·2991 | ·9879 | 22 | 20 | ·8817 | 753 |
| 697·7130 | 5 | 602·2870 | ·9901 | 22 | 22 | ·8795 | 754 |
| 698·7229 | 6 | 661·2771 | ·9924 | 23 | 20 | ·8775 | 755 |
| 699·7305 | 7 | 720·2695 | ·9947 | 23 | 22 | ·8753 | 756 |
| 700·7358 | 8 | 779·2642 | ·9969 | 22 | 20 | ·8733 | 757 |
| 701·7389 | 9 | 838·2611 | 58·9991 | 22 | 21 | ·8712 | 757 |
| 702·7398 | 10 | 897·2602 | 59·0013 | 22 | 21 | ·8691 | 758 |
| 703·7385 | 1 | 108956·2615 | ·0036 | 23 | 21 | ·8670 | 759 |
| 704·7349 | 2 | 109015·2651 | ·0058 | 22 | 21 | ·8649 | 760 |
| 705·7291 | 3 | 074·2709 | ·0081 | 23 | 20 | ·8629 | 761 |
| 706·7210 | 4 | 133·2790 | ·0102 | 21 | 21 | ·8608 | 762 |
| 707·7108 | 15 | 192·2892 | ·0125 | 23 | 21 | ·8587 | 763 |
| 708·6983 | 6 | 251·3017 | ·0147 | 22 | 21 | ·8566 | 763 |
| 709·6836 | 7 | 310·3164 | ·0170 | 23 | 20 | ·8546 | 764 |
| 710·6666 | 8 | 369·3334 | ·0191 | 21 | 21 | ·8525 | 765 |
| 711·6475 | 9 | 428·3525 | ·0214 | 23 | 21 | ·8504 | 766 |
| 712·6261 | 20 | 487·3739 | ·0235 | 21 | 21 | ·8483 | 767 |
| 713·6026 | 1 | 546·3974 | ·0258 | 23 | 20 | ·8463 | 768 |
| 714·5768 | 2 | 605·4232 | ·0280 | 22 | 20 | ·8443 | 769 |
| 715·5488 | 3 | 664·4512 | ·0301 | 21 | 21 | ·8422 | 769 |
| 716·5187 | 4 | 723·4813 | ·0324 | 23 | 21 | ·8401 | 770 |
| 717·4863 | 25 | 782·5137 | ·0346 | 22 | 20 | ·8381 | 771 |
| 718·4517 | 6 | 841·5483 | ·0367 | 21 | 20 | ·8361 | 772 |
| 719·4150 | 7 | 900·5850 | ·0390 | 23 | 21 | ·8340 | 773 |
| 720·3760 | 8 | 109959·6240 | ·0412 | 22 | 20 | ·8320 | 774 |
| 721·3348 | 9 | 110018·6652 | ·0433 | 21 | 21 | ·8299 | 774 |
| 722·2915 | 30 | 077·7085 | ·0455 | 22 | 20 | ·8279 | 775 |
| 723·2460 | 1 | 136·7540 | ·0477 | 22 | 21 | ·8258 | 776 |
| 724·1983 | 2 | 195·8017 | ·0499 | 22 | 20 | ·8238 | 777 |
| 725·1484 | 3 | 254·8516 | | | 20 | | 778 |

| −76°. | Diff. | Δ¹. | Δ². | Diff. | 77°. | ′ | −77°. | Diff. | Δ¹. |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 111850·0135 | | | 20 | 0·7679 | 161799·7428 | 0 | 115400·2572 | | 20 |
| | 59·1100 | 22 | | | | | | 59·2321 | |
| 909·1235 | | 20 | 19 | ·7660 | 800·5107 | 1 | 459·4893 | | 19 |
| | ·1120 | | | | | | | ·2340 | |
| 111968·2355 | | 21 | 20 | ·7640 | 801·2767 | 2 | 518·7233 | | 20 |
| | ·1141 | | | | | | | ·2360 | |
| 112027·3496 | | 22 | 20 | ·7620 | 802·0407 | 3 | 577·9593 | | 20 |
| | ·1163 | | | | | | | ·2380 | |
| 086·4659 | | 20 | 19 | ·7601 | 802·8027 | 4 | 637·1973 | | 19 |
| | ·1183 | | | | | | | ·2399 | |
| 145·5842 | | 22 | 19 | ·7582 | 803·5628 | 5 | 696·4372 | | 19 |
| | ·1205 | | | | | | | ·2418 | |
| 204·7047 | | 20 | 20 | ·7562 | 804·3210 | 6 | 755·6790 | | 20 |
| | ·1225 | | | | | | | ·2438 | |
| 263·8272 | | 22 | 20 | ·7542 | 805·0772 | 7 | 814·9228 | | 20 |
| | ·1247 | | | | | | | ·2458 | |
| 322·9519 | | 20 | 19 | ·7523 | 805·8314 | 8 | 874·1686 | | 19 |
| | ·1267 | | | | | | | ·2477 | |
| 382·0786 | | 21 | 19 | ·7504 | 806·5837 | 9 | 933·4163 | | 19 |
| | ·1288 | | | | | | | ·2496 | |
| 441·2074 | | | 20 | | 807·3341 | 10 | 115992·6659 | | 20 |
| | ·1309 | 21 | | ·7484 | | | | ·2516 | |
| 500·3383 | | 21 | 19 | | 808·0825 | 1 | 116051·9175 | | 19 |
| | ·1330 | | | ·7465 | | | | ·2535 | |
| 559·4713 | | 21 | 20 | | 808·8290 | 2 | 111·1710 | | 20 |
| | ·1351 | | | ·7445 | | | | ·2555 | |
| 618·6064 | | 20 | 19 | | 809·5735 | 3 | 170·4265 | | 19 |
| | ·1371 | | | ·7426 | | | | ·2574 | |
| 677·7435 | | 21 | 19 | | 810·3161 | 4 | 229·6839 | | 19 |
| | ·1392 | | | ·7407 | | | | ·2593 | |
| 736·8827 | | 21 | 19 | | 811·0568 | 15 | 288·9432 | | 19 |
| | ·1413 | | | ·7388 | | | | ·2612 | |
| 796·0240 | | 21 | 19 | | 811·7956 | 6 | 348·2044 | | 19 |
| | ·1434 | | | ·7369 | | | | ·2631 | |
| 855·1674 | | 20 | 20 | | 812·5325 | 7 | 407·4675 | | 20 |
| | ·1454 | | | ·7349 | | | | ·2651 | |
| 914·3128 | | 21 | 19 | | 813·2674 | 8 | 466·7326 | | 19 |
| | ·1475 | | | ·7330 | | | | ·2670 | |
| 112973·4603 | | 21 | 19 | | 814·0004 | 9 | 525·9996 | | 19 |
| | ·1496 | | | ·7311 | | | | ·2689 | |
| 113032·6099 | | | 19 | | 814·7315 | 20 | 585·2685 | | 19 |
| | ·1517 | 21 | | ·7292 | | | | ·2708 | |
| 091·7616 | | 20 | 20 | | 815·4607 | 1 | 644·5393 | | 20 |
| | ·1537 | | | ·7272 | | | | ·2728 | |
| 150·9153 | | 20 | 18 | | 816·1879 | 2 | 703·8121 | | 18 |
| | ·1557 | | | ·7254 | | | | ·2746 | |
| 210·0710 | | 21 | 20 | | 816·9133 | 3 | 763·0867 | | 20 |
| | ·1578 | | | ·7234 | | | | ·2766 | |
| 269·2288 | | 21 | 19 | | 817·6367 | 4 | 822·3633 | | 19 |
| | ·1599 | | | ·7215 | | | | ·2785 | |
| 328·3887 | | 20 | 18 | | 818·3582 | 25 | 881·6418 | | 18 |
| | ·1619 | | | ·7197 | | | | ·2803 | |
| 387·5506 | | 20 | 20 | | 819·0779 | 6 | 116940·9221 | | 20 |
| | ·1639 | | | ·7177 | | | | ·2823 | |
| 446·7145 | | 21 | 18 | | 819·7956 | 7 | 117000·2044 | | 18 |
| | ·1660 | | | ·7159 | | | | ·2841 | |
| 505·8805 | | 20 | 20 | | 820·5115 | 8 | 059·4885 | | 20 |
| | ·1680 | | | ·7139 | | | | ·2861 | |
| 565·0485 | | 21 | 18 | | 821·2254 | 9 | 118·7746 | | 18 |
| | ·1701 | | | ·7121 | | | | ·2879 | |
| 624·2186 | | | 19 | | 821·9375 | 30 | 178·0625 | | 19 |
| | ·1721 | 20 | | ·7102 | | | | ·2898 | |
| 683·3907 | | 21 | 19 | | 822·6477 | 1 | 237·3523 | | 19 |
| | ·1742 | | | ·7083 | | | | ·2917 | |
| 742·5649 | | 20 | 19 | | 823·3560 | 2 | 296·6440 | | 19 |
| | ·1762 | | | ·7064 | | | | ·2936 | |
| 801·7411 | | 20 | 19 | | 824·0624 | 3 | 355·9376 | | 19 |
| | ·1782 | | | ·7045 | | | | ·2955 | |
| 860·9193 | | 20 | 18 | | 824·7669 | 4 | 415·2331 | | 18 |
| | ·1802 | | | ·7027 | | | | ·2973 | |
| 920·0995 | | 21 | 20 | | 825·4696 | 35 | 474·5304 | | 20 |
| | ·1823 | | | ·7007 | | | | ·2993 | |
| 113979·2818 | | 20 | 18 | | 826·1703 | 6 | 533·8297 | | 18 |
| | ·1843 | | | ·6989 | | | | ·3011 | |
| 114038·4661 | | 20 | 19 | | 826·8692 | 7 | 593·1308 | | 19 |
| | ·1863 | | | ·6970 | | | | ·3030 | |
| 097·6524 | | 20 | 18 | | 827·5662 | 8 | 652·4338 | | 18 |
| | ·1883 | | | ·6952 | | | | ·3048 | |
| 156·8407 | | 21 | 19 | | 828·2614 | 9 | 711·7386 | | 19 |
| | ·1904 | | | ·6933 | | | | ·3067 | |
| 216·0311 | | | 19 | | 828·9547 | 40 | 771·0453 | | 19 |
| | ·1923 | 19 | | ·6914 | | | | ·3086 | |
| 275·2234 | | 21 | 18 | | 829·6461 | 1 | 830·3539 | | 18 |
| | ·1944 | | | ·6896 | | | | ·3104 | |
| 334·4178 | | 19 | 19 | | 830·3357 | 2 | 889·6643 | | 19 |
| | ·1963 | | | ·6877 | | | | ·3123 | |
| 393·6141 | | 21 | 19 | | 831·0234 | 3 | 117948·9766 | | 19 |
| | ·1984 | | | ·6858 | | | | ·3142 | |
| 452·8125 | | 20 | 18 | | 831·7092 | 4 | 118008·2908 | | 18 |
| | ·2004 | | | ·6840 | | | | ·3160 | |
| 512·0129 | | 20 | 18 | | 832·3932 | 45 | 067·6068 | | 18 |
| | ·2024 | | | ·6822 | | | | ·3178 | |
| 571·2153 | | 19 | 19 | | 833·0754 | 6 | 126·9246 | | 19 |
| | ·2043 | | | ·6803 | | | | ·3197 | |
| 630·4196 | | 21 | 19 | | 833·7557 | 7 | 186·2443 | | 19 |
| | ·2064 | | | ·6784 | | | | ·3216 | |
| 689·6260 | | 20 | 18 | | 834·4341 | 8 | 245·5659 | | 18 |
| | ·2084 | | | ·6766 | | | | ·3234 | |
| 748·8344 | | 19 | 18 | | 835·1107 | 9 | 304·8893 | | 18 |
| | ·2103 | | | ·6748 | | | | ·3252 | |
| 808·0447 | | | 19 | | 835·7855 | 50 | 364·2145 | | 19 |
| | ·2124 | 21 | | ·6729 | | | | ·3271 | |
| 867·2571 | | 19 | 18 | | 836·4584 | 1 | 423·5416 | | 18 |
| | ·2143 | | | ·6711 | | | | ·3289 | |
| 926·4714 | | 20 | 19 | | 837·1295 | 2 | 482·8705 | | 19 |
| | ·2163 | | | ·6692 | | | | ·3308 | |
| 114985·6877 | | 20 | 18 | | 837·7987 | 3 | 542·2013 | | 18 |
| | ·2183 | | | ·6674 | | | | ·3326 | |
| 115044·9060 | | 20 | 18 | | 838·4661 | 4 | 601·5339 | | 18 |
| | ·2203 | | | ·6656 | | | | ·3344 | |
| 104·1263 | | 19 | 18 | | 839·1317 | 55 | 660·8683 | | 18 |
| | ·2222 | | | ·6638 | | | | ·3362 | |
| 163·3485 | | 20 | 19 | | 839·7955 | 6 | 720·2045 | | 19 |
| | ·2242 | | | ·6619 | | | | ·3381 | |
| 222·5727 | | 20 | 18 | | 840·4574 | 7 | 779·5426 | | 18 |
| | ·2262 | | | ·6601 | | | | ·3399 | |
| 281·7989 | | 20 | 18 | | 841·1175 | 8 | 838·8825 | | 18 |
| | ·2282 | | | ·6583 | | | | ·3417 | |
| 341·0271 | | 19 | 18 | | 841·7758 | 9 | 898·2242 | | 18 |
| 115400·2572 | 59·2301 | | | 0·6565 | 161842·4323 | 60 | 118957·5677 | 59·3435 | |

| | ′ | −78°. | Diff. | Δ′. | Δ′. | Diff. | 77° |
|---|---|---|---|---|---|---|---|
| | | ″ | | | | ″ | ″ |
| 123 | 0 | 118957·5677 | | 18 | 16 | | 161878·9 |
| 170 | 1 | 119016·9130 | 59·3453 | 19 | 17 | 0·5204 | 879·1 |
| 198 | 2 | 076·2602 | ·3472 | 17 | 17 | ·5487 | 879·6 |
| 109 | 3 | 135·6091 | ·3489 | 19 | 16 | ·5470 | 880·2 |
| 101 | 4 | 194·9599 | ·3508 | 18 | 17 | ·5454 | 880·7 |
| 175 | 5 | 254·3125 | ·3526 | 17 | 16 | ·5437 | 881·3 |
| 132 | 6 | 313·6668 | ·3543 | 19 | 17 | ·5421 | 881·8 |
| 170 | 7 | 373·0230 | ·3562 | 18 | 17 | ·5404 | 882·4 |
| 190 | 8 | 432·3810 | ·3580 | 17 | 16 | ·5387 | 882·9 |
| 193 | 9 | 491·7407 | ·3597 | 19 | 16 | ·5371 | 883·4 |
| | | | ·3616 | | | ·5355 | |
| 177 | 10 | 551·1023 | | 17 | 16 | | 884·0 |
| 144 | 1 | 610·4656 | ·3633 | 18 | 17 | ·5339 | 884·5 |
| 193 | 2 | 669·8307 | ·3651 | 19 | 17 | ·5322 | 885·0 |
| 123 | 3 | 729·1977 | ·3670 | 17 | 15 | ·5305 | 885·6 |
| 136 | 4 | 788·5664 | ·3687 | 17 | 17 | ·5290 | 886·1 |
| 132 | 15 | 847·9368 | ·3704 | 19 | 17 | ·5273 | 886·6 |
| 109 | 6 | 907·3091 | ·3723 | 17 | 15 | ·5256 | 887·1 |
| 169 | 7 | 119966·6831 | ·3740 | 18 | 17 | ·5241 | 887·7 |
| 111 | 8 | 120026·0589 | ·3758 | 18 | 16 | ·5224 | 888·2 |
| 135 | 9 | 085·4365 | ·3776 | 17 | 16 | ·5208 | 888·7 |
| | | | ·3793 | | | ·5192 | |
| 142 | 20 | 144·8158 | | 18 | 16 | | 889·2 |
| 131 | 1 | 204·1969 | ·3811 | 18 | 16 | ·5176 | 889·8 |
| 102 | 2 | 263·5798 | ·3829 | 17 | 17 | ·5160 | 890·3 |
| 156 | 3 | 322·9644 | ·3846 | 18 | 16 | ·5143 | 890·8 |
| 192 | 4 | 382·3508 | ·3864 | 17 | 15 | ·5127 | 891·4 |
| 111 | 25 | 441·7389 | ·3881 | 18 | 17 | ·5112 | 891·9 |
| 112 | 6 | 501·1288 | ·3899 | 17 | 15 | ·5095 | 892·4 |
| 196 | 7 | 560·5204 | ·3916 | 18 | 17 | ·5080 | 892·9 |
| 162 | 8 | 619·9138 | ·3934 | 17 | 16 | ·5063 | 893·5 |
| 111 | 9 | 679·3089 | ·3951 | 18 | 15 | ·5047 | 894·0 |
| | | | ·3969 | | | ·5032 | |
| 142 | 30 | 738·7058 | | 17 | 17 | | 894·5 |
| 156 | 1 | 798·1044 | ·3986 | 18 | 15 | ·5015 | 895·0 |
| 152 | 2 | 857·5048 | ·4004 | 17 | 16 | ·5000 | 895·6 |
| 121 | 3 | 916·9069 | ·4021 | 17 | 16 | ·4984 | 896·1 |

| −79°. | Diff. | Δ². | Δ². | Diff. | 80°. | ′ | −80°. | Diff. | Δ² |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 122521·4098 | | 16 | 16 | | 161908·7539 | 0 | 126091·2461 | | 16 |
| | 59·4496 | | | 0·4550 | | | | 59·5450 | |
| 580·8594 | | 17 | 15 | | 909·2089 | 1 | 150·7911 | | 15 |
| | ·4513 | | | ·4535 | | | | ·5465 | |
| 640·3107 | | 17 | 15 | | 909·6624 | 2 | 210·3376 | | 15 |
| | ·4530 | | | ·4520 | | | | ·5480 | |
| 699·7637 | | 16 | 16 | | 910·1144 | 3 | 269·8856 | | 16 |
| | ·4546 | | | ·4504 | | | | ·5496 | |
| 759·2183 | | 17 | 14 | | 910·5648 | 4 | 329·4352 | | 14 |
| | ·4563 | | | ·4490 | | | | ·5510 | |
| 818·6746 | | 16 | 15 | | 911·0138 | 5 | 388·9862 | | 15 |
| | ·4579 | | | ·4475 | | | | ·5525 | |
| 878·1325 | | 17 | 16 | | 911·4613 | 6 | 448·5387 | | 16 |
| | ·4596 | | | ·4459 | | | | ·5541 | |
| 937·5921 | | 17 | 14 | | 911·9072 | 7 | 508·0928 | | 14 |
| | ·4613 | | | ·4445 | | | | ·5555 | |
| 122997·0534 | | 16 | 15 | | 912·3517 | 8 | 567·6483 | | 15 |
| | ·4629 | | | ·4430 | | | | ·5570 | |
| 123056·5163 | | 16 | 15 | | 912·7947 | 9 | 627·2053 | | 15 |
| | ·4645 | | | ·4415 | | | | ·5585 | |
| 115·9808 | | 16 | 15 | | 913·2362 | 10 | 686·7638 | | 15 |
| | ·4661 | | | ·4400 | | | | ·5600 | |
| 175·4469 | | 17 | 15 | | 913·6762 | 1 | 746·3238 | | 15 |
| | ·4678 | | | ·4385 | | | | ·5615 | |
| 234·9147 | | 17 | 15 | | 914·1147 | 2 | 805·8853 | | 15 |
| | ·4695 | | | ·4370 | | | | ·5630 | |
| 294·3842 | | 15 | 15 | | 914·5517 | 3 | 865·4483 | | 15 |
| | ·4710 | | | ·4355 | | | | ·5645 | |
| 353·8552 | | 17 | 14 | | 914·9872 | 4 | 925·0128 | | 14 |
| | ·4727 | | | ·4341 | | | | ·5659 | |
| 413·3279 | | 17 | 15 | | 915·4213 | 15 | 126984·5787 | | 15 |
| | ·4744 | | | ·4326 | | | | ·5674 | |
| 472·8023 | | 15 | 15 | | 915·8539 | 6 | 127044·1461 | | 15 |
| | ·4759 | | | ·4311 | | | | ·5689 | |
| 532·2782 | | 17 | 15 | | 916·2850. | 7 | 103·7150 | | 15 |
| | ·4776 | | | ·4296 | | | | ·5704 | |
| 591·7558 | | 16 | 14 | | 916·7146 | 8 | 163·2854 | | 14 |
| | ·4792 | | | ·4282 | | | | ·5718 | |
| 651·2350. | | 16 | 15 | | 917·1428 | 9 | 222·8572 | | 15 |
| | ·4808 | | | ·4267 | | | | ·5733 | |
| 710·7158 | | 16 | 15 | | 917·5695. | 20 | 282·4305 | | 15 |
| | ·4824 | | | ·4252 | | | | ·5748 | |
| 770·1982 | | 16 | 15 | | 917·9947 | 1 | 342·0053 | | 15 |
| | ·4840 | | | ·4237 | | | | ·5763 | |
| 829·6822 | | 17 | 14 | | 918·4184 | 2 | 401·5816 | | 14 |
| | ·4857 | | | ·4223 | | | | ·5777 | |
| 889·1679 | | 16 | 14 | | 918·8407 | 3 | 461·1593 | | 14 |
| | ·4873 | | | ·4209 | | | | ·5791 | |
| 123948·6552 | | 15 | 15 | | 919·2616 | 4 | 520·7384 | | 15 |
| | ·4888 | | | ·4194 | | | | ·5806 | |
| 124008·1440 | | 17 | 15 | | 919·6810 | 25 | 580·3190 | | 15 |
| | ·4905 | | | ·4179 | | | | ·5821 | |
| 067·6345. | | 15 | 14 | | 920·0989 | 6 | 639·9011 | | 14 |
| | ·4920 | | | ·4165 | | | | ·5835 | |
| 127·1265 | | 17 | 14 | | 920·5154 | 7 | 699·4846 | | 14 |
| | ·4937 | | | ·4151 | | | | ·5849 | |
| 186·6202 | | 16 | 15 | | 920·9305. | 8 | 759·0695 | | 15 |
| | ·4953 | | | ·4136 | | | | ·5864 | |
| 246·1155 | | 15 | 15 | | 921·3441 | 9 | 818·6559 | | 15 |
| | ·4968 | | | ·4121 | | | | ·5879 | |
| 305·6123 | | 17 | 14 | | 921·7562 | 30 | 878·2438 | | 14 |
| | ·4985 | | | ·4107 | | | | ·5893 | |
| 365·1108 | | 15 | 14 | | 922·1669 | 1 | 937·8331 | | 14 |
| | ·5000 | | | ·4093 | | | | ·5907 | |
| 424·6108 | | 16 | 15 | | 922·5762 | 2 | 127997·4238 | | 15 |
| | ·5016 | | | ·4078 | | | | ·5922 | |
| 484·1124 | | 16 | 14 | | 922·9840 | 3 | 128057·0160 | | 14 |
| | ·5032 | | | ·4064 | | | | ·5936 | |
| 543·6156 | | 16 | 14 | | 923·3904 | 4 | 116·6096 | | 14 |
| | ·5048 | | | ·4050 | | | | ·5950 | |
| 603·1204 | | 15 | 14 | | 923·7954 | 35 | 176·2046 | | 14 |
| | ·5063 | | | ·4036 | | | | ·5964 | |
| 662·6267 | | 17 | 15 | | 924·1990 | 6 | 235·8010 | | 15 |
| | ·5080 | | | ·4021 | | | | ·5979 | |
| 722·1347 | | 15 | 14 | | 924·6011 | 7 | 295·3989 | | 14 |
| | ·5095 | | | ·4007 | | | | ·5993 | |
| 781·6442 | | 15 | 14 | | 925·0018 | 8 | 354·9982 | | 14 |
| | ·5110 | | | ·3993 | | | | ·6007 | |
| 841·1552 | | 17 | 15 | | 925·4011 | 9 | 414·5989 | | 15 |
| | ·5127 | | | ·3978 | | | | ·6022 | |
| 900·6679 | | 15 | 13 | | 925·7989 | 40 | 474·2011 | | 13 |
| | ·5142 | | | ·3965 | | | | ·6035 | |
| 124960·1821 | | 16 | 15 | | 926·1954 | 1 | 533·8046 | | 15 |
| | ·5158 | | | ·3950 | | | | ·6050 | |
| 125019·6979 | | 15 | 14 | | 926·5904 | 2 | 593·4096 | | 14 |
| | ·5173 | | | ·3936 | | | | ·6064 | |
| 079·2152 | | 16 | 13 | | 926·9840 | 3 | 653·0160 | | 13 |
| | ·5189 | | | ·3923 | | | | ·6077 | |
| 138·7341 | | 15 | 15 | | 927·3763 | 4 | 712·6237 | | 15 |
| | ·5204 | | | ·3908 | | | | ·6092 | |
| 198·2545 | | 16 | 14 | | 927·7671 | 45 | 772·2329 | | 14 |
| | ·5220 | | | ·3894 | | | | ·6106 | |
| 257·7765 | | 16 | 14 | | 928·1565. | 6 | 831·8435 | | 14 |
| | ·5236 | | | ·3880 | | | | ·6120 | |
| 317·3001 | | 15 | 14 | | 928·5445. | 7 | 891·4555 | | 14 |
| | ·5251 | | | ·3866 | | | | ·6134 | |
| 376·8252 | | 15 | 14 | | 928·9311 | 8 | 128951·0689 | | 14 |
| | ·5266 | | | ·3852 | | | | ·6148 | |
| 436·3518 | | 16 | 14 | | 929·3163 | 9 | 129010·6837 | | 14 |
| | ·5282 | | | ·3838 | | | | ·6162 | |
| 495·8800 | | 16 | 13 | | 929·7001 | 50 | 070·2999 | | 13 |
| | ·5298 | | | ·3825 | | | | ·6175 | |
| 555·4098 | | 14 | 15 | | 930·0826 | 1 | 129·9174 | | 15 |
| | ·5312 | | | ·3810 | | | | ·6190 | |
| 614·9410 | | 16 | 13 | | 930·4636 | 2 | 189·5364 | | 13 |
| | ·5328 | | | ·3797 | | | | ·6203 | |
| 674·4738 | | 15 | 15 | | 930·8433 | 3 | 249·1567 | | 15 |
| | ·5343 | | | ·3782 | | | | ·6218 | |
| 734·0081 | | 16 | 13 | | 931·2215 | 4 | 308·7785. | | 13 |
| | ·5359 | | | ·3769 | | | | ·6231 | |
| 793·5440 | | 15 | 13 | | 931·5984 | 55 | 368·4016 | | 13 |
| | ·5374 | | | ·3756 | | | | ·6244 | |
| 853·0814 | | 15 | 15 | | 931·9740 | 6 | 428·0260 | | 15 |
| | ·5389 | | | ·3741 | | | | ·6259 | |
| 912·6203 | | 15 | 13 | | 932·3481 | 7 | 487·6519 | | 13 |
| | ·5404 | | | ·3728 | | | | ·6272 | |
| 125972·1607 | | 16 | 14 | | 932·7209 | 8 | 547·2791 | | 14 |
| | ·5420 | | | ·3714 | | | | ·6286 | |
| 126031·7027 | | 14 | 14 | | 933·0923 | 9 | 606·9077 | | 14 |
| | 59·5434 | | | 0·3700 | | | | 59·6300 | |
| 126091·2461 | | | | | 161933·4623 | 60 | 129666·5377 | | |

| 81°. | | −81°. | Diff. | Δ'. | Δ". | Diff. | |
|---|---|---|---|---|---|---|---|
| 933 4623 | 0 | 129666 5377 | | | | | 16195 |
| 933 8310 | 1 | 726 1690 | 59 6313 | 13 | 11 | 0 2914 | |
| 934 1983 | 2 | 785 8017 | 6327 | 14 | 13 | 2901 | |
| 5642 | 3 | 845 4358 | 6341 | 14 | 11 | 2890 | |
| 9288 | 4 | 905 0712 | 6354 | 13 | 13 | 2877 | 95 |
| 935 2920 | 5 | 129964 7080 | 6368 | 14 | 12 | 2865 | |
| 6539 | 6 | 130024 3461 | 6381 | 13 | 12 | 2853 | |
| 936 0145 | 7 | 083 9855 | 6394 | 13 | 12 | 2841 | |
| 3736 | 8 | 143 6264 | 6409 | 15 | 11 | 2830 | 95 |
| 7315 | 9 | 203 2685 | 6421 | 12 | 13 | 2817 | |
| | | | 6435 | 14 | 12 | 2805 | |
| 937 0880 | 10 | 262 9120 | 6449 | 14 | 11 | 2794 | 95 |
| 4431 | 1 | 322 5569 | 6462 | 13 | 13 | 2781 | |
| 7969 | 2 | 382 2031 | 6475 | 13 | 11 | 2770 | |
| 938 1494 | 3 | 441 8506 | 6488 | 13 | 12 | 2758 | |
| 5006 | 4 | 501 4994 | 6502 | 14 | 12 | 2746 | 957 |
| 8504 | 15 | 561 1496 | 6515 | 13 | 12 | 2734 | |
| 939 1989 | 6 | 620 8011 | 6529 | 14 | 11 | 2723 | |
| 5460 | 7 | 680 4540 | 6541 | 12 | 12 | 2711 | 958 |
| 8919 | 8 | 740 1081 | 6555 | 14 | 12 | 2699 | |
| 940 2364 | 9 | 799 7636 | 6568 | 13 | 11 | 2688 | |
| 5796 | 20 | 859 4204 | 6581 | 13 | 12 | 2676 | |
| 9215 | 1 | 919 0785 | 6594 | 13 | 12 | 2664 | 959 |
| 941 2621 | 2 | 130978 7379 | 6607 | 13 | 11 | 2653 | |
| 6014 | 3 | 131038 3986 | 6621 | 14 | 12 | 2641 | |
| 9393 | 4 | 098 0607 | 6633 | 12 | 12 | 2629 | |
| 942 2760 | 25 | 157 7240 | 6647 | 14 | 11 | 2618 | 960 |
| 6113 | 6 | 217 3887 | 6659 | 12 | 11 | 2607 | |
| 9454 | 7 | 277 0546 | 6673 | 14 | 12 | 2595 | |
| 943 2781 | 8 | 336 7219 | 6685 | 12 | 12 | 2583 | |
| 6096 | 9 | 396 3904 | 6698 | 13 | 10 | 2573 | 961 |
| 9398 | 30 | 456 0602 | 6711 | 13 | 12 | 2561 | |
| 944 2687 | 1 | 515 7313 | 6725 | 14 | 12 | 2549 | |
| 5962 | 2 | 575 4038 | 6737 | 12 | 11 | 2538 | |
| 9225 | 3 | 635 0775 | | 12 | 11 | | 962 |





| −82°. | Diff. | Δ². | Δ¹. | Diff. | 83°. | ′ | −83°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|
| ″ | ″ | | | ″ | ″ | | ″ | ″ | |
| 133246·7437 | 59·7086 | 11 | 12 | 0·2230 | 161968·6783 | 0 | 136831·3217 | 59·7770 | 12 |
| 306·4523 | ·7099 | 13 | 9 | ·2221 | ·9013 | 1 | 891·0987 | ·7779 | 9 |
| 366·1622 | ·7110 | 11 | 12 | ·2209 | 969·1234 | 2 | 136950·8766 | ·7791 | 12 |
| 425·8732 | ·7123 | 13 | 10 | ·2199 | ·3443 | 3 | 137010·6557 | ·7801 | 10 |
| 485·5855 | ·7135 | 12 | 10 | ·2189 | ·5642 | 4 | 070·4358 | ·7811 | 10 |
| 545·2990 | ·7147 | 12 | 11 | ·2178 | ·7831 | 5 | 130·2169 | ·7822 | 11 |
| 605·0137 | ·7159 | 12 | 11 | ·2167 | 970·0009 | 6 | 189·9991 | ·7833 | 11 |
| 664·7296 | ·7170 | 11 | 9 | ·2158 | ·2176 | 7 | 249·7824 | ·7842 | 9 |
| 724·4466 | ·7183 | 13 | 12 | ·2146 | ·4334 | 8 | 309·5666 | ·7854 | 12 |
| 784·1649 | ·7195 | 12 | 10 | ·2136 | ·6480 | 9 | 369·3520 | ·7864 | 10 |
| 843·8844 | ·7206 | 11 | 10 | ·2126 | ·8616 | 10 | 429·1384 | ·7874 | 10 |
| 903·6050 | ·7219 | 13 | 10 | ·2116 | 971·0742 | 1 | 488·9258 | ·7884 | 10 |
| 133963·3269 | ·7230 | 11 | 11 | ·2105 | ·2858 | 2 | 548·7142 | ·7895 | 11 |
| 134023·0499 | ·7242 | 12 | 10 | ·2095 | ·4963 | 3 | 608·5037 | ·7905 | 10 |
| 082·7741 | ·7254 | 12 | 10 | ·2085 | ·7058 | 4 | 668·2942 | ·7915 | 10 |
| 142·4995 | ·7266 | 12 | 11 | ·2074 | ·9143 | 15 | 728·0857 | ·7926 | 11 |
| 202·2261 | ·7277 | 11 | 10 | ·2064 | 972·1217 | 6 | 787·8783 | ·7936 | 10 |
| 261·9538 | ·7289 | 12 | 10 | ·2054 | ·3281 | 7 | 847·6719 | ·7946 | 10 |
| 321·6827 | ·7301 | 12 | 10 | ·2044 | ·5335 | 8 | 907·4665 | ·7956 | 10 |
| 381·4128 | ·7312 | 11 | 11 | ·2033 | ·7379 | 9 | 137967·2621 | ·7967 | 11 |
| 441·1440 | ·7324 | 12 | 9 | ·2024 | ·9412 | 20 | 138027·0588 | ·7976 | 9 |
| 500·8764 | ·7336 | 12 | 11 | ·2013 | 973·1436 | 1 | 086·8564 | ·7987 | 11 |
| 560·6100 | ·7347 | 11 | 10 | ·2003 | ·3449 | 2 | 146·6551 | ·7997 | 10 |
| 620·3447 | ·7359 | 12 | 10 | ·1993 | ·5452 | 3 | 206·4548 | ·8007 | 10 |
| 680·0806 | ·7371 | 12 | 9 | ·1984 | ·7445 | 4 | 266·2555 | ·8016 | 9 |
| 739·8177 | ·7382 | 11 | 11 | ·1973 | ·9429 | 25 | 326·0571 | ·8027 | 11 |
| 799·5559 | ·7393 | 11 | 10 | ·1963 | 974·1402 | 6 | 385·8598 | ·8037 | 10 |
| 859·2952 | ·7405 | 12 | 10 | ·1953 | ·3365 | 7 | 445·6635 | ·8047 | 10 |
| 919·0357 | ·7417 | 12 | 10 | ·1943 | ·5318 | 8 | 505·4682 | ·8057 | 10 |
| 134978·7774 | ·7427 | 10 | 9 | ·1934 | ·7261 | 9 | 565·2739 | ·8066 | 9 |
| 135038·5201 | ·7439 | 12 | 11 | ·1923 | ·9195 | 30 | 625·0805 | ·8077 | 11 |
| 098·2640 | ·7451 | 12 | 9 | ·1914 | 975·1118 | 1 | 684·8882 | ·8086 | 9 |
| 158·0091 | ·7462 | 11 | 10 | ·1904 | ·3032 | 2 | 744·6968 | ·8096 | 10 |
| 217·7553 | ·7473 | 11 | 10 | ·1894 | ·4936 | 3 | 804·5064 | ·8106 | 10 |
| 277·5026 | ·7484 | 11 | 10 | ·1884 | ·6830 | 4 | 864·3170 | ·8116 | 10 |
| 337·2510 | ·7496 | 12 | 10 | ·1874 | ·8714 | 35 | 924·1286 | ·8126 | 10 |
| 397·0006 | ·7507 | 11 | 9 | ·1865 | 976·0588 | 6 | 138983·9412 | ·8135 | 9 |
| 456·7513 | ·7518 | 11 | 10 | ·1855 | ·2453 | 7 | 139043·7547 | ·8145 | 10 |
| 516·5031 | ·7530 | 12 | 9 | ·1846 | ·4308 | 8 | 103·5692 | ·8154 | 9 |
| 576·2561 | ·7540 | 10 | 11 | ·1835 | ·6154 | 9 | 163·3846 | ·8165 | 11 |
| 636·0101 | ·7552 | 12 | 8 | ·1827 | ·7989 | 40 | 223·2011 | ·8173 | 8 |
| 695·7653 | ·7563 | 11 | 11 | ·1816 | ·9816 | 1 | 283·0184 | ·8184 | 11 |
| 755·5216 | ·7574 | 11 | 9 | ·1807 | 977·1632 | 2 | 342·8368 | ·8193 | 9 |
| 815·2790 | ·7584 | 10 | 10 | ·1797 | ·3439 | 3 | 402·6561 | ·8203 | 10 |
| 875·0374 | ·7596 | 12 | 9 | ·1788 | ·5236 | 4 | 462·4764 | ·8212 | 9 |
| 934·7970 | ·7607 | 11 | 9 | ·1779 | ·7024 | 45 | 522·2976 | ·8221 | 9 |
| 135994·5577 | ·7618 | 11 | 11 | ·1768 | ·8803 | 6 | 582·1197 | ·8232 | 11 |
| 136054·3195 | ·7629 | 11 | 8 | ·1760 | 978·0571 | 7 | 641·9429 | ·8240 | 8 |
| 114·0824 | ·7640 | 11 | 10 | ·1750 | ·2331 | 8 | 701·7669 | ·8250 | 10 |
| 173·8464 | ·7651 | 11 | 9 | ·1741 | ·4081 | 9 | 761·5919 | ·8259 | 9 |
| 233·6115 | ·7662 | 11 | 10 | ·1731 | ·5822 | 50 | 821·4178 | ·8269 | 10 |
| 293·3777 | ·7672 | 10 | 9 | ·1722 | ·7553 | 1 | 881·2447 | ·8278 | 9 |
| 353·1449 | ·7684 | 12 | 10 | ·1712 | ·9275 | 2 | 139941·0725 | ·8288 | 10 |
| 412·9133 | ·7694 | 10 | 9 | ·1703 | 979·0987 | 3 | 140000·9013 | ·8297 | 9 |
| 472·6827 | ·7705 | 11 | 9 | ·1694 | ·2690 | 4 | 060·7310 | ·8306 | 9 |
| 532·4532 | ·7715 | 10 | 9 | ·1685 | ·4384 | 55 | 120·5616 | ·8315 | 9 |
| 592·2247 | ·7727 | 12 | 9 | ·1676 | ·6069 | 6 | 180·3931 | ·8324 | 9 |
| 651·9974 | ·7737 | 10 | 10 | ·1666 | ·7745 | 7 | 240·2255 | ·8334 | 10 |
| 711·7711 | ·7748 | 11 | 9 | ·1657 | ·9411 | 8 | 300·0589 | ·8343 | 9 |
| 771·5459 | 59·7758 | 10 | 9 | 0·1648 | 980·1068 | 9 | 359·8932 | 59·8352 | 9 |
| 136831·3217 | | | | | 161980·2716 | 60 | 140419·7284 | | |

| | | −84°. | Diff. | Δ². | Δ¹. | Diff. | 84°. |
|---|---|---|---|---|---|---|---|
| | | ″ | ″ | | | ″ | ′ |
| 5 | 0 | 140419·7284 | 59·8361 | 9 | 75 | 0·11378 | 161988·3821 |
| 5 | 1 | 479·5645 | ·8370 | 9 | 75 | ·11303 | ·3896 |
| 5 | 2 | 539·4015 | ·8380 | 10 | 77 | ·11226 | ·4049 |
| 5 | 3 | 599·2395 | ·8388 | 8 | 75 | ·11151 | ·4200 |
| 7 | 4 | 659·0783 | ·8397 | 9 | 75 | ·11076 | 989·0317 |
| 0 | 5 | 718·9180 | ·8407 | 10 | 74 | ·11002 | ·1465 |
| 3 | 6 | 778·7587 | ·8415 | 8 | 75 | ·10927 | ·2013 |
| 8 | 7 | 838·6002 | ·8424 | 9 | 75 | ·10852 | ·3018 |
| 4 | 8 | 898·4426 | ·8433 | 9 | 73 | ·10779 | ·4703 |
| 1 | 9 | 140958·2859 | ·8442 | 9 | 74 | ·10705 | ·5787 |
| 9 | 10 | 141018·1301 | ·8451 | 9 | 74 | ·10631 | ·6851 |
| 8 | 1 | 077·9752 | ·8460 | 9 | 73 | ·10558 | ·7944 |
| 8 | 2 | 137·8212 | ·8469 | 9 | 73 | ·10485 | ·8970 |
| 9 | 3 | 197·6681 | ·8477 | 8 | 73 | ·10412 | 990·0019 |
| 2 | 4 | 257·5158 | ·8486 | 9 | 72 | ·10340 | ·1060 |
| 6 | 15 | 317·3644 | ·8495 | 9 | 73 | ·10267 | ·2094 |
| 1 | 6 | 377·2139 | ·8504 | 9 | 71 | ·10196 | ·3121 |
| 7 | 7 | 437·0643 | ·8512 | 8 | 73 | ·10123 | ·4140 |
| 5 | 8 | 496·9155 | ·8521 | 9 | 71 | ·10052 | ·5153 |
| 1 | 9 | 556·7676 | ·8530 | 9 | 71 | ·09981 | ·6158 |
| 4 | 20 | 616·6206 | ·8538 | 8 | 71 | ·09910 | ·7158 |
| 5 | 1 | 676·4744 | ·8547 | 9 | 71 | ·09839 | ·8147 |
| 9 | 2 | 736·3291 | ·85555 | 85 | 70 | ·09769 | ·9131 |
| 35 | 3 | 796·18465 | ·85639 | 84 | 71 | ·09698 | 991·0108 |
| 96 | 4 | 856·04104 | ·85725 | 86 | 69 | ·09629 | ·1077 |
| 71 | 25 | 915·89829 | ·85810 | 85 | 71 | ·09558 | ·2040 |
| 51 | 6 | 141975·75639 | ·85894 | 84 | 68 | ·09490 | ·2996 |
| 57 | 7 | 142035·61533 | ·85979 | 85 | 70 | ·09420 | ·3945 |
| 88 | 8 | 095·47512 | ·86063 | 84 | 70 | ·09350 | ·4887 |
| 25 | 9 | 155·33575 | ·86146 | 83 | 67 | ·09283 | ·5822 |
| 79 | 30 | 215·19721 | ·86231 | 85 | 69 | ·09214 | ·6750 |
| 48 | 1 | 275·05952 | ·86314 | 83 | 69 | ·09145 | ·7671 |
| 34 | 2 | 334·92266 | ·86396 | 82 | 67 | ·09078 | ·8586 |



86



| | −85°. | Diff. | Δ². | Δ². | Diff. | 86°. | | −86°. | Diff. | Δ². |
|---|---|---|---|---|---|---|---|---|---|---|
| ′ | ″ | ″ | | | ″ | ″ | ′ | ″ | ″ | |
| 0 | 144011·41881 | | 75 | 61 | | 161994·15277 | 0 | 147605·84723 | | 61 |
| | | 59·88622 | | | 0·07277 | | | | 59·92723 | |
| 1 | 071·30503 | ·88697 | 75 | 60 | ·07217 | ·22554 | 1 | 665·77446 | ·92783 | 60 |
| 2 | 131·19200 | ·88774 | 77 | 60 | ·07157 | ·29771 | 2 | 725·70229 | ·92843 | 60 |
| 3 | 191·07974 | ·88849 | 75 | 61 | ·07096 | ·36928 | 3 | 785·63072 | ·92904 | 61 |
| 4 | 250·96823 | ·88924 | 75 | 59 | ·07037 | ·44024 | 4 | 845·55976 | ·92963 | 59 |
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## "Further Observations on Nova Persei. No. 4." By Sir NORMAN LOCKYER, K.C.B., F.R.S. Received October 10, 1901.

The last paper* contained an account of the observations of the Nova made at Kensington between March 25 and May 7. The observations are, in the present paper, brought up to September 30. Between June 18 and August 8 no work was done on the Nova, owing chiefly to the interference of buildings and twilight.

* 'Roy. Soc. Proc.,' vol. 68, p. 399.

*Magnitude.*

has been estimated on sixteen evenings. These seem
evidence that since the beginning of May the star
nagnitude from about 5·7 to 6·7; further, the short
sly recorded apparently no longer exist, as the esti-
on eleven nights since the end of August only vary
·8.

the region about the Nova were taken with the
doublet on the evenings of August 25 and September
From these it has been ascertained that its magnitude
of the surrounding stars is greater photographically

*Visual Spectrum.*

has been observed with a McClean direct-vision
he evenings of August 8, 13, 17, 20, 22, 24, and
18. The line in the position of the chief nebular
always been noted as being the strongest, H$\beta$ and
being also present, but comparatively much weaker.
near $\lambda$ 472 and the region of H$\gamma$ have also been
of a few lines less refrangible than $\lambda$ 5007 have been
determinations of their wave-lengths have been
ave been observed in the yellow or red regions of the

The spectrum has undergone great modification since the last photographs were taken at Kensington in March and April. The lines are about the same in number and position, but their nature and relative intensities have vastly changed. In the latter part of March and the early part of April the lines were generally broad and ill-defined. They are now narrower, and with better defined edges. The greatest change noticeable in the spectrum is with respect to the relative weakening of the hydrogen lines generally and the alteration in relative intensity amongst some of them. In the earlier photographs the hydrogen lines were very prominent, and the individual members of the series gradually weakened as the ultra-violet part of the spectrum was approached. In the latest photographs they appear of quite secondary importance. H$\beta$, H$\gamma$, and H$\delta$ are all present, but occur only as comparatively weak lines, especially the latter two. With regard to H$\epsilon$, apparently the only other hydrogen line shown, the case is different. The line at or near the position of H$\epsilon$ is now about the second strongest line in the whole photographic spectrum, and many times stronger than either H$\delta$, H$\gamma$, or H$\beta$. With this fact in view, it may be suggested that this strong line is possibly not wholly due to hydrogen, but is mainly a new line of unknown origin, which happens to fall exactly on, or very near to, the position of H$\epsilon$. The line appears to be of much the same nature as the stronger adjacent line at $\lambda$ 3868. The following table gives the wave-lengths and intensities of the lines visible in the photographs:—

| $\lambda\lambda$. | Int. (max. = 10). | Remarks. |
|---|---|---|
| 3868 | 10 | Strong line in spectrum of planetary nebulæ. |
| 3970 | 8 | Probably not wholly due to hydrogen (H$\epsilon$), intensity abnormal. |
| 4102 | 2 | H$\delta$. |
| 4341 | 2 | H$\gamma$. |
| 4364 | 7 | |
| 4471 | 1 | Helium. |
| 4636 | 3 | |
| 4684 | 2 | Probably identical with 4687 of $\zeta$ Puppis and Orion stars. |
| 4720 | 6 | |
| 4808 | $<1$ | |
| 4862 | 3 | H$\beta$. |
| 4959 | 2 | Apparently identical with second nebula line. |
| 5007 | 4 | „ „ strongest „ |

In addition to the lines in the above table, six of the photographs including that of August 26, give indications of the presence of a line in the extreme ultra-violet. Its wave-length could not be obtained

f accuracy owing to lack of comparison photographs
the same part of the spectrum, but it is probably
line at λ 342 which von Gothard has independently

ines of iron, magnesium, &c., which were such a con-
f the earlier photographs of the Nova spectrum, have
ppeared, and the probability is that the bright lines
pectrum other than those of hydrogen and helium
the terrestrial equivalents of which have not been
be mentioned, however, that in their paper "On the
nore Volatile Gases of Air,"† Professors Liveing and
ak lines at λλ $\frac{4363}{4365}$ and 4636 which may possibly
emical origin as the Nova lines 4364 and 4636.
ndication of the new lines forming a series similar to
drogen and helium, there is probably more than one

*acteristics of the Hydrogen and other Lines.*

photographs under discussion, the hydrogen lines no
curious structure described in previous communica-
ch fainter and rather narrower and devoid of any
es in density. Some of the bright lines—notably
70—are of about the same width as the adjacent

images of neighbouring stars of equal magnitude. This peculiarity of the Nova's disc was first remarked by Flammarion and Antoniadi, and later by Max Wolf, Kostinsky, and von Gothard. It owes its origin probably to the exceptionally strong ultra-violet rays emitted by the Nova, which are not brought to the focus for which the objective is corrected.

The recent photographs have been taken by Mr. Butler and Mr. Rolston. The visual observations have chiefly been made by Messrs. Fowler and Butler. Mr. Baxandall has undertaken the reduction to wave-lengths and the discussion of the lines in the photographic spectrum, while Dr. Lockyer and Mr. Baxandall have assisted in the preparation of the present paper.

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"Total Solar Eclipse of 1901 May 17–18. Preliminary Report of the Observations made at Ayer Karoe, Sawah Loento, Sumatra." By H. F. NEWALL, M.A. Received October 30,—Read at Joint Meeting of the Royal and Royal Astronomical Societies, October 31, 1901.

This expedition was one of those organised by the Joint Permanent Eclipse Committee of the Royal Society and Royal Astronomical Society, funds being provided from a grant made by the Government Grant Committee.

It was originally contemplated that the party should consist of Professor H. H. Turner and myself, and that we should occupy a station inland in Sumatra; but when the former found himself unable to join in the expedition, it was decided not to appoint another observer in his stead, nor to fix upon the station to be occupied until there was an opportunity of learning about local conditions on the spot.

The expedition was to go to Padang, on the West Coast of Sumatra, and to this port I travelled in company with Mr. F. W. Dyson, who went out from the Royal Observatory, Greenwich. It was decided that we should travel out together, prepared either to join forces at one and the same camp, or to form two camps separated by a considerable distance, and our ultimate decision was to depend upon information which we expected to get from the Dutch authorities.

I had communicated with Major Muller, the Chief of the Survey

tavia, with reference to a possible site for a camp at
tation about 40 miles inland on the State Railway),
twards near the Oembilien coalfields; for it seemed
he east side of the Barisan Mountains would be more
ourable conditions of weather in May than stations
an opinion based on careful study of both Dr. van der
on 'Wind, Weather, &c., in the Indian Archipelago'
and also of the summary published by the Dutch
ociety over the names of Major Muller and Dr. Figee,
n of observers. I may say at once that the reality
pinion, based on averages, was not worth much, for
s seemed, at any rate in 1901, to play a comparatively
letermination of weather.

sen for getting to Sumatra was that *vid* Genoa, and
Royal Mail steamship *vid* Red Sea direct to Padang,
oted to the Nederland Steamship Company for con-
n in fares in consideration of the scientific object of
. Dyson and I and my wife left Charing Cross on
velled across the Continent together, and were joined
J. J. Atkinson, who had generously volunteered to go
ion to Sumatra to assist in the observations and
e had done in the previous year with the Astronomer
Portugal. We went on board the Dutch mail-steamer
ates," and sailed from Genoa on March 14. The
e route were that it took us in the shortest possible
ir port Padang lying on the track of the moon's

On arrival at Padang on Saturday, April 6, we made the acquaintance of the Governor of the West Coast of Sumatra and of Major Muller, head of the Survey Department, and Mr. Delprat, the head of the State Railways. The Governor received us on the following Monday morning, and we recall with great pleasure the personal courtesy and friendly helpfulness which he at once extended to us. Nothing could exceed the kindness and consideration which we experienced throughout our stay in the island from the Dutch authorities with whom it was our good fortune to come in contact. I may here add that I took the opportunity, which was afforded me by a visit to Java after the eclipse, to express to the Governor-General of the Dutch Indies the informal thanks of the English observers for the generous assistance which had been given to them in their expedition.

We were indebted to Professor Bakhuysen, the President of the Dutch Committee, for several sets of maps of the admirable survey of the West Coast of Sumatra. The local authorities at Padang added to our obligations by presenting us with free passes for ourselves and freight over all the railway system on the West Coast.

The Governor of the West Coast arranged that Mr. Dyson and Mr. Atkinson should make use of his steam launch to inspect possible sites for a camp on the coast in Trusan Bay, and also on an island 6 miles from the coast opposite Painan. Mr. Delprat was able to give me information and much kind assistance in the matter of sites inland near the Oembilien coalfield, and I at once set off to Sawah Loento with introductions to Mr. van Lessen, the Chief Engineer of the mines.

Thus it came about that when Mr. Dyson and I met again at Padang on the following Thursday, April 11, we had gained such information that we were able to decide at once that we should occupy separate camps (i) Mr. Dyson, together with Mr. Atkinson, on the island Aoer Gadang, assisted by H.M.S. "Pigmy," a gunboat commanded by Lieutenant-Commander Oldham, R.N., which, in response to an application from the Royal Society, had been told off by the Admiralty to render assistance to the observers; and (ii) myself inland, on tolerably high ground, not far from Sawah Loento, the last station on the railway, at the mouth of the Oembilien coal mines, and thus quite on the east side of the Barisan Range. Our stations were thus the most widely separated in Sumatra, Mr. Dyson being at the west end of the line, and the first of the Sumatran observers to be immersed in the moon's shadow, whilst I was furthest inland at the east end of the line.

The rest of this report deals with my own experiences and observations.

It was with regret that I had to decline the invitation of the Boston

orces with them; they had chosen an excellent site outh of Sawah Loento, but it was at a considerable living quarters, and it seemed to me that in that could not afford to spend much of our forces in , for the somewhat extensive programme of obser- uire much preparation. Under the guidance of e Chief Engineer at the mines, an excellent site was und above the mines to the N.W. of Sawah Loento; n was good enough to put at my disposal a house had recently been built for the use of officers of ch had not yet been occupied. The house was close hich mine-viewers were living, and, moreover, other g built in their neighbourhood. Hence the con- very respect very great, for the conditions implied would be easily got, water was laid on, and build- ready to hand. The house was built on a terrace evelled on the hillside, and I decided to set up the nts within a few feet of the verandah.

indebted to Mr. van Lessen for his kind assistance ys. Not only did he make me free to use the ines and the coolies employed there, for the purpose huts and building piers for the instruments, but he en helped us in setting up house in rather unusual lending us furniture and in enlisting a similar kind- lent "Comptrolleur," Mr. Sieburgh. It is a pleasure ness and interest with which the officers of the mines

### § 3. *Time Observations.*

From the top of a small hillock within two minutes' walk of the instruments we could see the camp of the Boston expedition near Sawah Loento, at a distance of 2·7 miles (measured on the Survey maps 1 : 20,000). Professors Burton and Hosmer were so kind as to make an arrangement by which we received time signals and so determined the errors and rates of the chronometer and watch which I had brought with me. Professor Hosmer had a white time-ball fixed that could easily be seen against the dark background of the tropical foliage with the help of binoculars; and it was arranged that on any day that we hung out a signal (three white flags) in the early morning, he would if possible drop the time-ball at $11^h\ 5^m\ 0^s$, again at $11^h\ 6^m\ 0^s$ and at $11^h\ 7^m\ 0^s$. His time observations for determining the errors and rates of his own chronometers were made with a $2\frac{1}{2}$-inch portable transit and chronograph. Mr. Hosmer gave me signals on four days between the 9th and 19th of May. My watch—an excellent one by Frodsham, made for the 1862 Exhibition—was kept in exceptionally favourable conditions for good time-keeping, and its rate deduced from signals received on May 9 and 16 was + 4·6 seconds per diem, and from May 16 and 19 was + 4·6 seconds per diem.

The rate of the chronometer (by Crisp) was found to have changed from + $0^s{\cdot}7$ between the 17th and 18th to + $2^s{\cdot}1$ between 18th and 19th, the chronometer having been moved in and out of the hut several times for the preparatory rehearsals.

The following are the times of contacts observed, those predicted from the elements given in the 'Nautical Almanac' being given for comparison and position-angles of the contacts being also added for convenience of record:—

| | Position angle. | Prediction, G.M.T. | Observed. |
|---|---|---|---|
| | ° | hr. min. sec. | hr. min. sec. |
| First contact .. | 253 | 16 5 15 | 16 5 31 |
| Second ,, .. | 48 | 17 39 12 | 17 39 17 |
| Third ,, .. | 288 | 17 44 54 | 17 44 52 |
| Fourth ,, .. | 82 | 19 17 20 | Not observed |

First contact was observed by me through the declination theodolite, the time of my call "Now" (possibly 5 seconds late) being noted on the Crisp chronometer by Lieutenant Briggs. Second and third contacts are those for Dr. Wallace's signal "Go" at beginning of totality when he was observing the disappearing current on the focussing plate of the Dallmeyer telephotographic camera (image of sun 1·43 inches in diameter) and for my signal "Now" given to Lieutenant

Newall for the exposures they had to make with nstruments for the reappearing flash.

ervations were recorded in terms of the metronome onnected with the chronometer readings by my noting :er the instant at which the last call of the count with 'as made by the time-keeper.

e was adjusted to beat seconds the night before the t it lost one beat in 6 minutes. It was tested about our before the eclipse, and again after the eclipse, and :everal trials to lose between one and two beats in

phs of the disappearing and reappearing crescents these signals called both by Dr. Wallace and myself. n is not yet completed.

§ 4. *Meteorological Conditions.*

summary may be given of the records kept between y 22 :—

–Out of 23 days on which record was kept of the the sky near the zenith between 12 and 1 o'clock pse occurred at 12.22 P.M.—

:ely free from cloud and haze (May 1).
'om cloud, but more or less hazy.
etely overcast.
or less cloudy (including the day of the eclipse).

Largest rainfalls recorded were:—

| | | |
|---|---|---|
| May 8 ..... | 1·19 inches | in 40 minutes. |
| „ 22 ..... | 1·72 „ | 2 hours. |

§ 5. *General Programme of the Observations.*

The operations during the eclipse were to include—

1. Taking a series of photographs of the corona with the Dallmeyer telephotographic combination, in continuation of the series obtained in many recent eclipses, under the direction of the Joint Permanent Eclipse Committee.
2. Taking a series of photographs of the corona with the Savart camera, used at Algiers in 1900, for a study of the polarisation of the corona.
3. Taking a series of photographs of polarised images of the coronal with the double-image camera, devised and used by Professor H. H. Turner in recent eclipses.

   Nos. 1, 2, and 3 were to be done with the "double-tube" camera, which had been used in many eclipses. Professor Turner had very kindly lent me the apparatus for No. 3, but I had most reluctantly to give up the attempt to adjust it; the weather in the week before the eclipse was unpropitious, and I had to concentrate effort on completing adjustment of instruments already set up.
4. Taking a series of photographs of the spectrum of the chromosphere and "flash" at the beginning and end of totality, with a 4-prism spectroscope with slit, for accurate determination of wave-lengths.
5. Taking a photograph of the spectrum of the corona with the 4-prism spectroscope, two slits being used, to get material for the determination of the relative motion of the eastern and western parts of the corona (rotation of the corona).
6. Taking photographs of the "flash" and corona, with a powerful objective-grating camera, using very high dispersion.
7. Making visual observations of the structure of the green coronal ring, as viewed through another objective grating camera.
8. Taking photographs of the spectrum of the flash and corona with a quartz spectrograph giving small dispersion.
9. Making visual observations of the atmospheric polarisation with a view to detecting a change in the plane of polarisation during totality, and for the purpose of getting the information necessary for adjusting the Savart camera used in No. 2 during the eclipse.

§ 6. *Assistance.*

ıe preparations for the observations I received most
:e from my friend Dr. L. Wallace, who travelled from
tra especially to help in the work of the expedition.
ah Loento on April 18, he accompanied us to Ayer
ed in every possible way to further the aims of the
the moment of his arrival until all the instruments
again on May 26 after the eclipse. It is a great
wledge my deep indebtedness to him for his friendly
.

:fore the eclipse, Lieutenant-Commander Oldham, of
' was good enough to tell off Lieutenant H. D. Briggs
ıyer Karoe, together with two petty officers from the
p in the final preparations, and in the observations.
ı the preparatory drills and rehearsals, and gave most
e.

tions during the eclipse itself—

as in charge of the double tube camera, and gave the
; the diminishing crescent of the sun upon the blue
' the Dallmeyer telephotographic camera.

D. Briggs exposed the plates for the objective-grating
ving assisted me in making the final adjustment with
rescent.

ade exposures with the quartz spectrograph.

discussion of eclipse observations were true, Dr. Downing, the Superintendent of the 'Nautical Almanac,' having been good enough to write out to us in Sumatra about this result of the discussion. It was arranged that Hobart should continue the counting of seconds after totality was finished, so that I might note on the chronometer the instant at which the final "sixty" was called.

The operations were rehearsed several times on the two days before the eclipse, and everything went off as perfectly as rehearsals could make it. In a later paragraph reference will be made to one unforeseen mishap which arose from the interference of the clouds.

### § 7. *The Day of the Eclipse.*

When the sun rose and the morning mists were dispelled on the 18th—the day of the eclipse—the conditions seemed vastly more favourable than on any day in the previous week, during which it must be confessed we had rather a trying time, inasmuch as sunshine was needed for the final adjustment of the two spectroscopes, and it was very difficult to find moments between clouds when enough could be got.

The early hours of the morning of the 18th were occupied in completing the adjustments, which, as it turned out, were already nearly perfect, except in the case of the quartz spectrograph, as will appear in a later paragraph. The clocks for driving the cœlostat and the large spectrograph were finally rated, and we had gathered for a last rehearsal, more for the sake of establishing confidence than of adding to the instruction and drill, which had been gone through many times on the two previous days. But about 11 o'clock, very soon after I had observed the first contact, clouds began to move up from the N.E., and to form round the sun, and it began to be an anxious time. I was content to dispense with the rehearsal in dumb-show, and thus avoided the risk of inadvertent exposure of the photographic plates in the dark slides, preferring to give some finishing touches to the arrangements for signals, exposures, and observations. Nothing was lost by this procedure, and in the actual event the programme was perfectly carried out by everyone concerned, except that cloud interfered in an unforeseen way (see § 11, p 221) with my operations with the 4-prism spectrograph, thus curtailing my most important exposure by 2¼ minutes, and also involving the loss of one of the exposures with the double tube.

Fifteen minutes before totality the cloud was still hanging about, and obviously forming in some places and dispersing in others. Iris-coloured rings were seen round the diminishing crescent, showing that the clouds were water-clouds, not ice-cirrus. Ten minutes before totality I looked into one of the spectrographic instruments (see

Dr. Common and silvered by the Improved Electric
pany, had a very fine surface, which was found in
ion when it was unpacked and put into its mounting
the preliminary adjustments of the polar axis of the
been made by means of the attached declination-
recent eclipses. Dr. Common kindly lent me a 6-inch
s mirror (also silvered by the above-named Company),
ce or twice before May 14, temporarily fitted to the
coelostat; for it seemed safer in the tropical climate
isk as possible with the 16-inch mirror, though I had,
ndness of Mr. Hinks, taken out silvering solutions in
he final adjustment of the polar axis of the instrument
ter the large mirror had been put in position in the
lls for no special mention.

e mirror—*i.e.*, the perpendicularity of its normal to
was tested by making the polar axis horizontal, as
dings of the level on the theodolite, and then com-
ngs of a small level carefully placed on a sheet of
vered surface of the mirror, with the readings of the
This procedure was regarded as sufficient and satis-
ce close to the equator, though exception might be
it adopted in higher latitudes.

1. *The 4-prism Spectroscope with two Slits.*

I to attempt

parallel to the collimator. The axis is rotated (with a period of 24 hours) by clockwork, and is tilted so as to be parallel to the earth's axis. It was adjusted so that the collimator pointed to the south pole and the camera to the north pole.

The tube of the collimator is prolonged beyond the plane of the slit, and is arranged to carry at its end a mirror of speculum metal and an object-glass, by means of which an image of the sun can be thrown between the two slits.

The whole arrangement thus consists of a spectroscope combined with a polar heliostat, and in virtue of the fact that the spectroscope is rotated together with the mirror, the image of any celestial object thrown on the slit does not rotate relatively to the slit. The mirror is mounted in such a manner that the axis about which it is tilted can be oriented relatively to the collimator tube, so that the slits may be set parallel to any diameter of the sun. On the present occasion the slits were set parallel to the axis of the sun.

In India the slits were set at too great a distance apart, and the light of the corona was not strong enough to impress the photographic plate; the slits were set so as to catch the corona nearly 8′ from the sun's limb on each side. In Algiers the instrument was used with only one slit, and the spectrum of the corona was photographed in two regions to a distance $3\frac{1}{4}'$ from the limb with an exposure of 49 seconds, and the resulting negative was a good strong one. In Sumatra I expected to be able to get an exposure of 270 or even 300 seconds, and to avoid risk of disappointment the slits were set at such a distance apart as to catch the corona 3′ from the sun's limb on each side. This distance was as small as it seemed wise to adopt, account being taken of the apparent diameter and movement of the moon during totality.

The instrument was fairly well adjusted on May 2, and I then took the opportunity afforded by a clear night to throw an image of the full moon on to the slits. It was brightly seen and easily adjusted; but to make matters more certain, I painted the slit-plate white, so that there might be no possible difficulty in setting the image of the corona between the slits after the exposures had been made for the "flash" spectrum with the crescent across one of the slits. The sequel will show that even this precaution was not enough under the circumstances.

The adjustment of the axis of the instrument to parallelism with the earth's axis was accomplished in the same way as in India and Algiers by means of a theodolite with declination circle and level, which was attached to a part of the frame of the spectroscope specially prepared for it.

The rotating plate-holder, charged with twelve small plates, was again used for the exposures as in Algiers.

the diminishing crescent through the guiding eye-
roscope when Dr. Wallace called out "Stand by,"
ened to the plate-holder to make exposures for the
posures had been made, each twice as long as I had
had there been no cloud, and as the counting went
anticipated I decided to make one more exposure,
h plate at the beginning of totality. Immediately
d Plate No. 7 into its place with shutter closed, I
uiding eye-piece to set the corona ring between the
one side of the faint ring distinctly, but could not
having learnt by experiment in the course of the
ovements of the declination and R.A. slow-motions
move the image from one position to the other, I
nents and, being still unable to see the slits, looked
There was no difficulty in seeing the dark moon, so
corona was quite indistinct beneath the cloud, and
a colourless bright ring, which is referred to in the
s." My notes, written directly after the eclipse, con-
:—

t 'Thirty,' and took a candle lamp [which was
nt] to try to illuminate the slit-plate, but failed to
, as 'Thirty-five' was called, I turned to polariscope.
sation. Turned to second polariscope and could see
risation, but saw mackerel sky very strong as it
egion near the sun, especially to N.E. . . . Return-

shutter sticking rather. Then re-set bright side of corona according to picture [previously made to indicate position angle of crescent on slit], and began to expose the five remaining plates in 4-prism [for second 'flash']. At $5^m$ $35^s$ I called 'Now' to Briggs and Mrs. N. for their final photographs, when I felt end of totality had come . . . [I turned to chronometer and waited for] W.'s signal 'Now,' which was to mean the 15-seconds crescent [of returning sun]. I noted this on chronometer, and waited further for Hobart's final 'Sixty,' which I also noted on the chronometer. Called 'Cover slides,' and then went out of hut and saw mackerel cloud all over the sky near the sun and 'glory' rings coloured round crescent. Sky got rapidly more clouded, and clouds drifted slowly towards west. Collected notes from observers."

*Summary of Exposures.*—Six exposures were made near second contact with the following durations :—

1 second, 1 second, 2 seconds, 2 seconds, 2 seconds, 3 seconds.

The seventh plate was exposed for the corona spectrum for $2^m$ $18^s$. Five exposures were made near third contact with the following durations :—

2 seconds, 2 seconds, 1 second, 1 second, 1 second.

*Results.*—Of the twelve plates thus exposed, only four plates show any impress of the light. The rest, including the exposure on the corona, show nothing, though development was pressed as far as possible.

Five minutes before totality a photographic plate was exposed for 15 seconds to get the spectrum of the sunlight reflected from the clouds near the crescent—this was to serve to give standard measurements to which the measures of the corona spectrum were to be referred—and a good strong negative was obtained.

The plates at second contact are very feeble negatives, and I attribute their weakness to cloud. Photographs obtained with the other instruments at the beginning of totality show that at least three-quarters of the light was intercepted by cloud.

The spectrum of the corona failed because of insufficient exposure under the cloudy conditions.

The plates at the end of totality, when there was certainly very much less cloud, show no sign of impress of the light, and I can only explain it by assuming that the image of the reappearing crescent must have been set across the slit in such a way that three or four more exposures than I had the means of giving were needed to catch the reappearing chromosphere. Photographs obtained with the objective grating show that there was plenty of light to impress the plate, if only it had passed into the slit.

2. *Dallmeyer Telephotographic Camera.*

era used by Professor Turner at Sahdol in 1898 and was used on the present occasion in the modified lgiers. One of the 7 × 7-inch tubes contained the bjective No. 2, of 4-inch aperture and 5-feet focal meyer secondary magnifier of 7½ inches focus, placed he focus, giving an image of the sun 1·43 inches in $6\frac{1}{4} \times 6\frac{1}{4}$ inches.

opted for focussing was first to focus on trees on a iewed through blue glass, and then to use the colli- opted in many recent eclipses. A plane mirror set he axis of the camera reflects rays emerging from the in through the objective; the image of objects in the formed in the focal plane. The mirror used on the as the 6-inch kindly lent to me by Dr. Common, and lly prepared with an image of a finely graduated black ground, was used as the object to be focussed te, which was put in the same plane with it. Four t data to set the focus accurately.

ained in the eclipse are as satisfactory as the lenses ems right to suggest that some other lenses be used, ake this kind of photograph of the corona in future

of exposures with this camera was of necessity the

In the event, the long exposure was sacrificed, the other five were made.

The actual exposures were :—

1. 8 seconds, beginning 10 seconds after the signal "Go."
2. 17 „ „ 2 minutes 35 seconds after the signal "Go."
3. 36 „ „ 3 „ 15 „ (? ± 5 seconds).
4. Omitted.
5. 4 seconds, beginning 5 minutes 3 seconds after the signal "Go."
6. 2 „ „ 5 „ 18 „ „ „

The first exposure was made through clouds.

The interval between the first and second exposures was more than 2 minutes longer than it would have been had the sky been clear. In the third exposure one of the shutters had evidently not acted, the photograph showing nothing but the standard squares, which had been put on just before development. The last two exposures were carried out according to programme, and were made probably at moments when the sky was clearer than at any other time during the whole eclipse.

*The Standard Squares.*—After the eclipse, Sir. W. Abney's standard squares were impressed on all the plates for photometric measurements. Exposures were made to a standard candle at 5 feet from the plate, and, following a suggestion made by Professor Turner after his experience with the plates taken at Algiers in 1900, two sets of squares were impressed, with different exposures, on all the plates, as follows :—

| Plate. | Exposure for corona. | Exposure for standard squares. |
|---|---|---|
| No. 1 | 8 seconds | 10 seconds and 5 seconds |
| „ 2 | 17 „ | 20 „ 5 „ |
| „ 3 | 36 „ | 80 „ 5 „ |
| „ 4 | not exposed | 80 „ 5 „ |
| „ 5 | 4 seconds | 80 „ 5 „ |
| „ 6 | 2 „ | 20 „ 5 „ |

*Development.*—All the plates were developed with metol.

When it was found that there was no image on No. 3—one of the exposing shutters evidently had not acted—it was thought wise to impress squares on No. 4, and develop it, just for the very improbable chance that it had been exposed in mistake for No. 3, but no image appeared on the plate.

*Results.*—The four photographs obtained are all good clean plates. The effect of the cloud is clearly seen in the plates, though it is surprising that the definition has not been more affected by it. The first exposure (8 seconds) shows less than the last (2 seconds),

(17 seconds) shows very little more than the fifth

ıe corona is clearly of the type associated with the unspot cycle.

ıatorial region shows great disturbance, and there are ominences on the eastern limb and several marked ıular, reference may be made to (i) two dark rifts ıe neighbourhood of a prominence near the sun's ast side; (ii) bright and dark arches in no less than rants, extending about 4′ from the limb; (iii) a dark g a large prominence whose position-angle is approxi- red from the N. point of the sun; and (iv) a remark- as of a chromospheric layer for a considerable arc of the N.W. quadrant, such as Sir Norman Lockyer n the photographs secured in Spain last year.

ɣiven below of the extension noted in the different ɜnsion being measured beyond the *moon's* limb, and tes of arc :—

| | Plate No. 1. 8 seconds. | No. 2. 17 seconds. | No. 5. 4 seconds. | No. 6. 2 seconds. |
|---|---|---|---|---|
| ıers ..... | 5′ | 15′ | 21′ | 5′ |
| ..... | 8 | 23 | 19 | 8 |
| ..... ..... | 5 | 22 | 12 | 9 |

The cameras were focussed on trees on a distant hill viewed through blue glass, and gave satisfactory images.

The programme of exposures was the same as that for the Dallmeyer telephotographic camera, as follows :—

8 seconds, 16 seconds, 32 seconds, 120 seconds, 4 seconds, 2 seconds,

thus including one long exposure, and five others in geometrical progression, it being intended to compare the polarised image on one plate with the unpolarised image on the plate next before it in the series. The Savart was to be set in accordance with the result of visual observations of the atmospheric polarisation, so that the bands due to atmospheric polarisation should be obliterated. The first photograph was made with an arbitrary setting of the Savart, and the setting chosen was one that would give the coronal bands slightly inclined to the sun's equator. In the event no atmospheric polarisation was detected, and the Savart was left at the same setting throughout all the exposures. Mr. Wallace made simultaneous exposures for these and for the Dallmeyer telephotographic camera.

*Results.*—As in the case of the Dallmeyer telephotographic camera, four photographs were obtained, standard squares being impressed on each plate after the eclipse with a standard candle at 5 feet.

| | Exposure for corona. | Exposure for standard squares. |
|---|---|---|
| No. 1 | 8 seconds | 10 seconds and 5 seconds |
| „ 2 | 17 „ | 20 „ 5 „ |
| „ 5 | 4 „ | 20 „ 5 „ |
| „ 6 | 2 „ | — „ 5 (one only). |

All the photographs with the Savart camera are good clean plates and show marked polarisation of the corona. The following table summarises the extensions of the coronal streamers in the unpolarised images and of the bands in the polarised.

Extensions expressed in Minutes of Arc from Moon's Limb.
P = Polarised Image. U = Unpolarised.

| Plate..... | No. 1. | | No. 2. | | No. 5. | | No. 6. | |
|---|---|---|---|---|---|---|---|---|
| Exposure ..... | 8 seconds. | | 17 seconds. | | 4 seconds. | | 2 seconds. | |
| | U. | P. | U. | P. | U. | P. | U. | P. |
| North polar streamers | 8′ | ? | 20′ | 28′(?) | 15′ | 10′(?) | 8′ | ? |
| East equatorial ..... | 13 | 5?′ | 46 | 69 | 29 | 28 | 15 | 10′ |
| West „ ..... | 8 | 49 | 41 | 97 | 29 | 34 | 20 | 23 |
| South polar ..... | 5 | ? | 16 | ? | 11 | ? | 8 | ? |

extensions in the unpolarised images no account was
which it seemed fair to attribute to diffusion from
n was gauged along *streamers*, not in structureless
many cases bands can be traced in the polarised
an streamers in the unpolarised.

go Sir G. G. Stokes pointed out that the Savart
be used for the detection of faint extensions of the
ay be that these photographs give evidence of the
gestion.

k moon very faint bands are detectable only in the
re. I am not yet prepared to say how far the
results may lead me to attribute the extension of
diffusion of polarised light which emanates from the
rial clouds, but it is clear that the resultant polarisa-
must be, so far as the Savart bands are concerned, in a
the equatorial extensions.

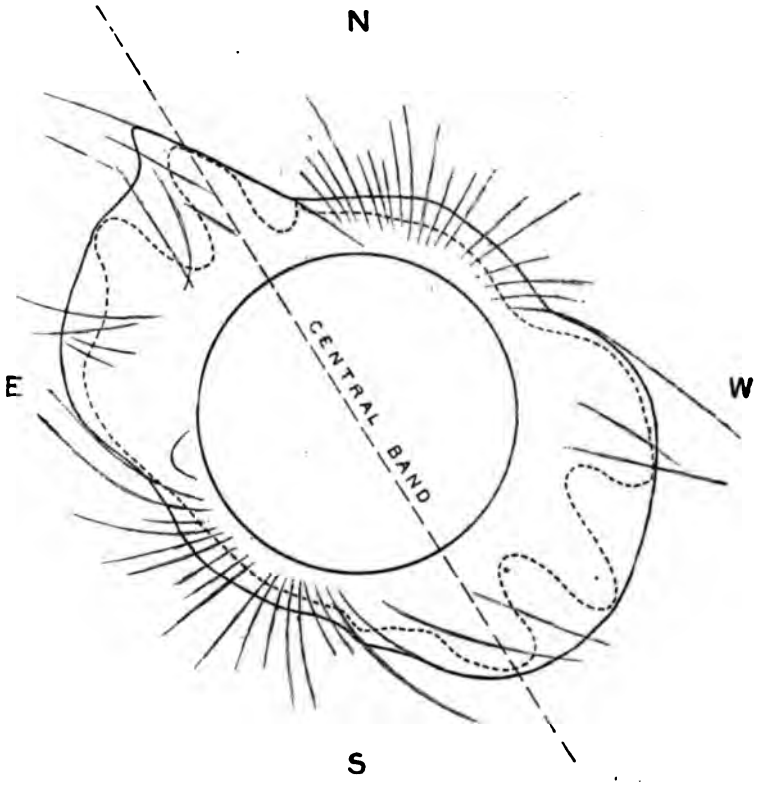
he photographs, *as a series*, with related exposures is
with by the variation in the effect produced by cloud,
ce it will hardly be possible to utilise them for finding
from the sun there is the maximum relative polarisa-
he impressed extensions great enough. But as each
posures made on it simultaneously, one of the polarised
the unpolarised, it is anticipated that they will serve
ermination of the amount of polarisation in many
rona.

ying figure (fig. 1) indicates the contours of equal

eclipsed sun could be seen through them. Each was mounted in a turning tube, provided with a pointer and graduated circle and attached to a wooden stand.

The programme of observations was that I should look through A as soon after the beginning of totality as the adjustment and exposures of the 4-prism spectroscope would set me free. The polariscope was to be then turned in its tube until the Savart bands were invisible, and

Fig. 1.




I was at once to set the large photographic Savart camera to the corresponding reading, and to call out to Mr. Wallace, who was making the exposures for that camera.

Next the polariscope B was to be used half-way through totality, when my visual observations with the grating-spectroscope were completed. Finally the polariscope C was to be used towards the end of totality, just before the fifth minute was completed. Each of the polariscopes was to be left as adjusted "for extinction," and the readings were to be made at leisure after the eclipse, except in the case of A, of which the readings were needed at once.

ıe event I used A about 40 seconds after the beginning found no trace of polarisation in any position of the o make sure that nothing was wrong I used also polari- rroborated the first observation.

end of the third minute—$2^m$ $50^s$ from the beginning of n observed with B. At the end ofthe fifth minute I used ıer case could I detect a trace of atmospheric polarisation. ı., after the eclipse was over, I used the polariscopes ıd them all as adjusted in the morning before the ıe showed showed strong bands on the patches of blue ıe field of view.

§ 15. *The Quartz Spectrograph.*

ed to attempt to get—

ıphs of the ultra-violet spectrum of the flash at the ıing and end of totality.

graph of the ultra-violet spectrum of the corona.

ent was fixed on the top of the double tube, and was t from the cœlostat. The arrangement was such that e set, without readjustment of the image, to catch the t beginning and end of totality, and the corona during ther medium but quartz was used in the lenses and dimensions were such that a 2-inch beam was trans-

The instrument employed was in essentials that used at Algiers in 1900, but it was mounted differently.

A plane grating by Rowland, 14,438 lines to the inch on a ruled surface $5 \times 3\frac{1}{2}$ inches, was fitted on an axis in front of a telescope of aperture 4 inches and focal length 66·8 inches. The grating is a very brilliant one; the objective is an excellent one, corrected for photographic rays, by Cooke and Sons; and both belong to the splendid spectroscopic installation arranged by the late Professor Piazzi Smyth. I am under great obligation to the Royal Society for the continued loan of this outfit.

The telescope with grating attached was fixed inclined at an angle of 20° to the horizontal and pointing downwards on the sloping pier which supported the double camera, the telescope and camera being parallel. Part of the beam reflected by the cœlostat was allowed to fall on a 6-inch mirror, and thereby reflected downwards on to the grating. By inclining the plane of this reflection by the proper amount with the vertical, it was possible to get the crescent at second contact symmetrically disposed with respect to the plane of dispersion of the grating. It was thought best to run the risk involved in the loss of light for the sake of getting the telescope into the very convenient position of parallelism with the double camera, and on the same sloping pier with it.

The light reflected by the small mirror fell upon the grating with an incidence of 39°, and the diffracted beam left the grating at an angle of about 5° on the other side of the normal. In this position $H_\gamma$ in the spectrum of the second order was not far from the centre of the field of view of the telescope.

The focussing and final adjustment of the spectrum on the focussing plate was intentionally left to be done a few minutes before totality, when the width of the diminishing crescent would make it possible to recognise the exact part of the spectrum in the field of view. Ten minutes before totality the cloud was so obscuring that on looking into the eye-piece I could not distinguish between the spectrum of the crescent and light reflected from the clouds. Returning to the instrument 6 minutes later I found the lines visible, and Lieutenant Briggs, who was to take charge of the exposures with this instrument, turned the tilting screw of the grating till I could see that the dark crescent-shaped lines near $\lambda$ 4231 were in the centre of the field. I then focussed very carefully, and handed over the instrument to Lieutenant Briggs.

*Programme.*—Exposures were to be made—

(i) For 1 second when the signal "Stand by" was called by Dr. Wallace 15 seconds before totality.

(ii) For 2 seconds when the count "Thirteen" was called before totality.

minutes, starting at the count "Thirty" after the tality and ending at the count "Sixty,—five minutes

conds, when I gave the signal "Now" at the end of

Briggs carried out the programme with admirable

Four photographs are of value. The first serves for the scale of the spectrum and shows that the focussing sful. The second and fourth photographs show both lines, as was intended; the second is a weak negative, teresting details; the fourth is quite strong, teeming cents, of which more than ninety have been counted and λ 4405. Many of the crescents are bright through- length; many are reversed in the middle; some of nts are accompaned by dark crescents on either side; ark crescent only on one side or the other; all varieties sented.

otograph is not very strong but it shows marked con- n, with the blue coronal ring distinctly though not easily ges are ill-defined, in marked contrast with the sharp that serve to mark out the positions of the $H_\gamma$ and ic rings.

tension of the blue coronal ring is about 3′, but there

surface $3\frac{1}{2} \times 2\frac{1}{8}$ inches, was fixed on a turn-table in front of a telescope of aperture $3\frac{1}{2}$ inches, and focal length 29 inches. A positive eye-piece with two cross-wires was used, which gave a magnifying power of 19·2, and whose circular field of view was rather more than 1° in diameter.

The instrument was mounted so that the telescope was parallel to the earth's axis and pointed to the south pole. The grating was used in a manner analogous to that in which the mirror of a polar heliostat is used. The light of the corona was incident at an angle of about 57°, and the diffracted beam utilised in the telescope left the grating at an angle of about 13°. In this position of the grating, the green of the second order was used and the magnifying power of the grating was approximately one-half, so that the distorted coronal ring was an ellipse, of which the major axis was about twice as long as the minor axis, the minor axis being parallel to the length of the spectrum and perpendicular to the direction of daily motion. No clockwork was used, but a wedge pushed under a wooden arm fixed to the instrument and projecting radially outwards from the telescope served to give a satisfactory slow motion by slightly turning the whole instrument about what may be described as polar pivots.

The instrument was focussed on the E group of lines about two minutes before totality began. The crescent was small enough to show the lines sharply, though the instrument was so set that the point of second contact was near the end of the major axis of the distorted image.

When I came to make observations of the green coronal ring, I first looked very carefully for fine radial structure; and finding none, I altered the focus very slightly. This did not improve matters, so I reverted to the original focussing, and am quite satisfied about the observation, which could not be more definite.

The observations were begun after the completion of the third minute of totality and were completed in about 80 seconds. Two ellipses had been drawn beforehand to serve as outline for the distorted limb of the moon; and on one of these the record of contour lines of the brightness was quickly but carefully sketched.

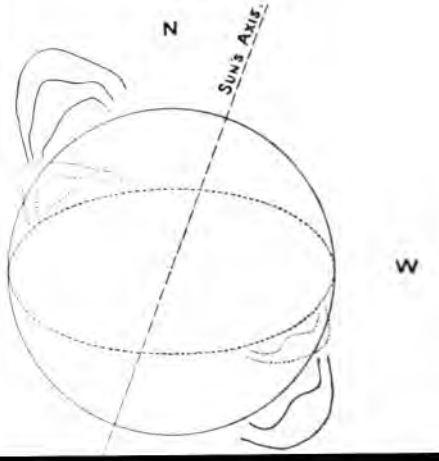
*Results.*—The coronal ring was distinctly seen, but there was a good deal of other green light throughout the whole of the field of view, doubtless from clouds. No fine radial structure could be seen anywhere round the ring; but there were two broad patches of the light of "coronium" projecting from the elliptical ring.

The accompanying figure (fig. 2) shows by the dotted lines the ellipse drawn beforehand, and the contour lines as sketched in during the eclipse. The unbroken lines indicate the results got by projecting the ellipse into a circle and making the corresponding change in the contour lines.

§ 18. *General Observations.*

rkness during totality was greater than that in India, iers in 1900, but not so much greater as was antici- reat length of duration of totality. No integrating ised. Lamps and candles were provided in case of might have been dispensed with except for one

FIG. 2.



"Total Eclipse of the Sun, 1901 May 18. Preliminary Account of the Observations made at Pulo Aoer Gadang, West Coast of Sumatra." By F. W. DYSON, M.A., F.R.S., Sec. R.A.S. Received October 24,—Read at Joint Meeting of the Royal and Royal Astronomical Societies, October 31, 1901.

## I. *General Arrangements.*

The Admiralty having approved of expeditions from the Royal Observatory to observe the Solar Eclipse of 1901, May 18, I was instructed by the Astronomer Royal to occupy a station on the West Coast of Sumatra with the instruments used at Ovar in the eclipse of 1900, May 28. Mr. J. J. Atkinson, who accompanied the Observatory expedition to Ovar, again generously volunteered his assistance and is associated with me in all the observations. His advice and co-operation were of the greatest value throughout.

The programme of observations, which was arranged in concert with the Joint Permanent Eclipse Committee, was essentially the same as that carried out at Ovar.

The 16-inch cœlostat and the 4-inch rapid rectilinear (Abney) lens were lent by the Royal Astronomical Society, and Captain Hills kindly lent the spectrosopic equipment he used at the Indian eclipse, viz., a two prism flint spectroscope, a four prism quartz spectroscope, and a 12-inch heliostat.

At the request of the Royal Society the Admiralty placed H.M. gunboat "Pigmy" at the service of the observers in Sumatra. We are indebted to Lieut. and Com. Oldham for the ready manner in which he assented to our request to anchor off Gadang, and let us live on the "Pigmy." Without his cordial co-operation this station could not have been occupied. We are further indebted to him and to the officers and men of the "Pigmy" for assistance in erecting the huts and instruments, and for the large share they took in the observations on the day of the eclipse.

We received every assistance from the Government of the Dutch East Indies in the choice of station and arrangement with the natives, and were given free passes for ourselves and instruments on the railways. We are specially indebted to Mr. Joekes, the Governor of the West Coast of Sumatra, to Mr. Von Locken, the Assistant Resident at Painan, to Major Müller, the Director of the Ordnance Survey and Chief of the Dutch eclipse party, and to Mr. Delprât, the Director of Railways.

*Itinerary.*—The observing huts and instruments having been despatched some days previously, the 16-inch cœlostat mirror and some of the photographic plates were taken to Southampton and put

on board the Dutch mail steamer "Koningen Regentes," at Southampton, on March 4. The observers joined the ship at Genoa, on March 14, and sailed in company with Mr. and Mrs. Newall, the Dutch eclipse party, and an American eclipse party from the Massachusetts Institute of Technology, direct to Padang in Sumatra, arriving there on April 6.

In consultation with Mr. Joekes the Governor of the West Coast and Major Müller the Director of the Ordnance Survey as to choice of station, it appeared that the small island of Pulo Aoer Gadang might be suitable, and the Governor kindly offered us the use of his yacht to visit the island on March 10. In company with Mr. Von Locken we chose a suitable site and made the necessary arrangements with the native chief who owned the island. Lieut. and Com. Oldham conveyed us with our instruments and materials for building huts to Gadang on March 13, and remained anchored off Gadang, except for short necessary visits to Padang for ice, fresh meat, &c., till May 25, one week after the eclipse. On this day the instruments were brought back to Padang for shipment to Europe, and the observers were conveyed to Singapore, which was reached in the early morning of June 2.

*Station.*—The particularly uncertain character of the weather in Sumatra made it desirable that stations as far apart as possible should be occupied by the different parties of observers. The stations occupied by different expeditions are shown on the accompanying map (A).

*Sawah Loento*, by Mr. Newall and by a party from the Massachusetts Institute of Technology.

*Solok*, by numerous American observers of the United States Naval Observatory expedition.

*Fort de Koch*, by American and Dutch observers.

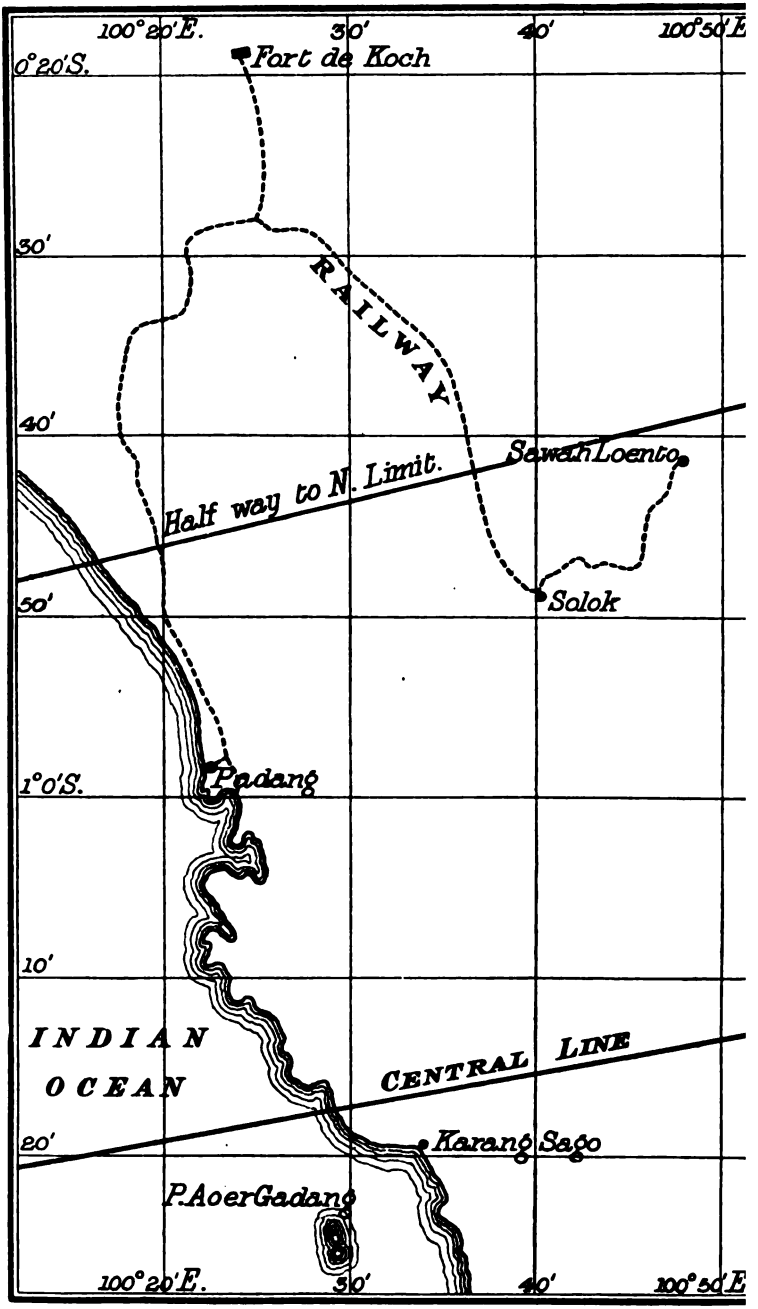
*Padang*, by the Lick Observatory party, French, Russian, and Japanese observers.

*Karang Sago*, by the Dutch party.

*Aoer Gadang*, by the Royal Observatory.

The presence of the "Pigmy" made it possible to occupy Aoer Gadang. This station had the advantage of being as far away as possible from the mountain range which runs parallel to the west coast of Sumatra. Solok and Sawah Loento are to the east of this range.

Aoer Gadang is a small island about 1 mile long and $\frac{1}{4}$ mile broad, surrounded by a coral reef. The site chosen for the eclipse camp was a small clearing near the eastern shore opposite a passage through the reef. Its position, as determined from large scale maps published by the Government of the Dutch East Indies, is lat. 1° 23′ 28″ S., and long. 100° 29′ 13″ E. of Greenwich. It is about 7 miles distant from


100°20′E.
30′
40′
100°50′E
0°20′S.
Fort de Koch
30′
RAILWAY
40′
Sewah Loento
Half way to N. Limit.
50′
Solok
1°0′S.
Padang
10′
INDIAN
OCEAN
CENTRAL LINE
20′
Karang Sago
P. Aoer Gadang
100°20′E.
30′
40′
100°50′E

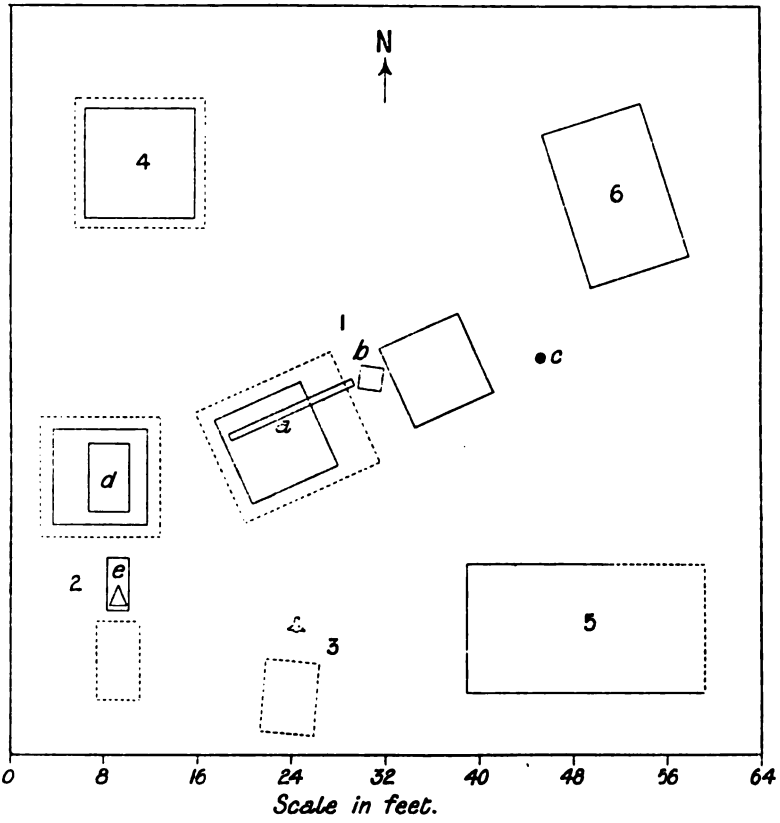
*d*

miles distant from the camp of the Dutch observers
nd 30 miles from Padang.

*Huts and Instruments.*—The same light wooden frames
esden waterproof canvas which were used at Ovar in
00, May 28, were taken out to Sumatra, with an
serve as a developing room.* As a protection against
se were supplemented by sheds, built in Malay style,
thatched with *atap*, a species of palm leaf, which is
laths about 4 feet long.

, 14 feet long and 12 feet broad, and 12 feet high at
l one of the two canvas huts and half of the second
e Thompson coronagraph and the 16-inch cœlostat
at Ovar, the hut over the cœlostat was moved back
observations. Thatch was tacked on the roof of this
ds were fixed over the spectroscope hut and over the
. Thatch was also tacked all over the developing
in addition to black waterproof paper inside, served
n light-tight. Movable sheds, each resting on four
re placed over the heliostat and condensing lenses of
and over the Dallmeyer photoheliograph. A house
p was also built, open on the east side and partly on
ch hammocks were swung, and where the observers
hen the "Pigmy" was obliged to leave for a short
s also erected for the two marines who were left on
servers by Lieut. and Com. Oldham on such occasions.

PLAN OF ECLIPSE STATION AT AOER GADANG, 1901 MAY 18.




1. { *a*. Thompson coronagraph.
   *b*. Cœlostat.
   *c*. Palm-tree to which clock-weight was attached.
2. { *d*. Spectroscopes.
   *e*. Heliostat.
3. Double photographic camera.
4. Developing room.
5. Observer's house.
6. Men's tent.

*Personnel.*—The following list gives the names of those who took part in the observations:—

F. W. Dyson—Quartz spectroscope, Thompson coronagraph.

J. J. Atkinson—Flint spectroscope.

Lieut. and Com. Oldham—Double camera for small-scale photographs. Observed duration.

Lieut. Frewen—Gave signals of beginning and end of totality. Observation of stars.

send—Set heliostat for corona spectrum, and again
t.
)—Exposed at object glass of Thompson coronagraph.
n.
n the "Pigmy" also assisted; two counting seconds
metronome; one exposing in front of the condensing
troscope; one exposing in front of the object glasses
nera; and three assisting in handing plate holders to
aptain Oldham.
procedure, which was carefully rehearsed on several
sly, was as follows: The observers were stationed
ents, and Lieut. Frewen watched the diminishing
scent of the sun on the ground glass of the corona-
paper scale on which the lengths of the crescent were
l at intervals of $3^m$, $2^m$, $1^m$, $30^s$, $20^s$, $10^s$ before totality.
tality Mr. Frewen called out "Stand by," and the
n had been carefully rated, was started. At $1^m$ before
out "Get ready." At the words "Thirty seconds"
Mr. Atkinson drew out the dark slides ready for
word "Ten" the exposures for the "flash" spectrum
the word "Now" given at the moment of totality
corded by Lieut. Oldham and Dr. Nimmo. Six
lity Mr. Dyson and Mr. Atkinson changed the plates
nd exposed for the corona spectrum, Mr. Townsend
on the slit by the heliostat. Mr. Dyson then went

| | Local time. hrs. | mins. | secs. | Reading of thermometer. ° |
|---|---|---|---|---|
| Beginning of eclipse ..... | 10 | 48 | 0 | — |
| | 11 | 0 | 0 | 88·8 |
| | 11 | 17 | 0 | 86·0 |
| | 11 | 30 | 0 | 85·0 |
| | 11 | 45 | 0 | 84·3 |
| | 12 | 0 | 0 | 81·8 |
| | 12 | 20 | 0 | 79·0 |
| Beginning of totality ..... | 12 | 19 | 30 | — |
| End of totality..... | 12 | 26 | 50 | — |
| | 13 | 25 | 0 | 84·9 |
| | 13 | 40 | 0 | 84·9 |
| | 13 | 53 | 0 | 88·0 |
| End of eclipse ..... | 13 | 58 | 0 | — |

As the temperature usually rose from 90° to 92°, there would seem to have been a fall of temperature of from 10° to 13° due to the eclipse.

The duration of the eclipse was observed by Captain Oldham as $6^m\ 20^s{\cdot}5$, and by Dr. Nimmo as $6^m\ 21^s{\cdot}5$. These times agree with those obtained by the Dutch observers at Karang Sago, who give for the duration $6^m\ 22^s$.* These times are $10^s$ less than that given in the Nautical Almanac, but agree closely with a prediction kindly forwarded by Dr. Downing (based on a value of 15′ 31″·47 for the mean semi-diameter of the Moon, derived from a recent discussion of eclipse observations), viz., $6^m\ 20^s$.

At the commencement of totality at Aoer Gadang a signal was flashed across to the Dutch eclipse camp by the "Pigmy" search-light, thus giving them a warning $16^s$ before totality occurred at their station.

During totality the sky was much darker than at Ovar in the eclipse of 1900, May 28. Venus, Mercury, and Aldebaran were seen. The corona appeared to be white; the polar plumes and the prominences were distinctly seen.

*Development of the Photographs.*—As stated in a previous paragraph, a fully equipped dark room was taken out to Sumatra. It was found before the eclipse that considerable care was needed in the development of photographs owing to the high temperature. Immediately after the eclipse the "Pigmy" went to Padang, returning the next day with 250 lbs. of ice. The photographs were developed on May 19 and five following nights. Thanks to the untiring assistance of Mr. Curtain, gunner of the "Pigmy," the development of the thirty-seven

* 'Proceedings of the Koninklijke Akademie van Wetenschappen te Amsterdam, 1901,' p. 87.

:h was a somewhat trying and arduous matter, was satisfactorily, only one failure of any consequence

II. *Photographs of the Corona.*

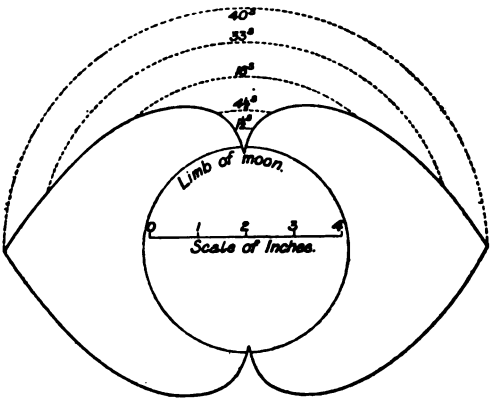
: of observations was composed of two distinct parts: ıs of the corona on a large scale to show structural

ıs on a smaller scale with rapid lenses, to show the with the greatest possible extension, and to photo- nd the Sun for the detection of an intra-Mercurial : exist.

*Photographs.*—The instrument used was the Thompson scope with object glass of 9 inches aperture and :al length, belonging to the Royal Observatory, in a concave telephoto lens by Dallmeyer, of 4 inches inches focus, fitted as a secondary magnifier, to give sun 4 inches in diameter, with a field (for full ches. The total length of the coronagraph was ralent focal length being about 36 feet. The focus by the method used by the Astronomer Royal at 396, 1898, and 1900, by means of the image of a plane of the plate reflected from the plane mirror of n the determination of the focus, which was done at ain, warrant officer, rendered great assistance. A

in the centre $\frac{3}{4}$ inch in diameter, through which a spindle, mounted on the back of the plate carrier, was passed. On this spindle the screen was fixed in the dark room after the plate had been put in the carrier.

Occulting Shutter for Photographs of Corona by Burckhalter's Method.




The figures against the dotted lines show the effective exposures at different distances from the Sun's centre.

During the exposure, the observer turned a small handle about once a second, which, by a suitable train of wheels, caused the screen to turn about eight times a second. The apparatus appears to work perfectly smoothly, as the limb of the Moon is sharply defined on the photographs taken.

The eight slides were exposed as below, the exposures being made at the object glass by Dr. Nimmo:

| | Exposure. | | | Plate. | |
|---|---|---|---|---|---|
| | Beginning. | End. | Duration. | | |
| | m. s. | m. s. | secs. | | in. |
| 1 | 0 30 | 0 40 | 10 | Mawson Photo-mechanical. | 12 × 10 |
| 2 | 1 0 | 1 10 | 10 | Edwards' Ordinary. | 12 × 10 |
| 3 | 1 20 | 1 40 | 20 | Ilford Empress. | 15 × 15 |
| 4 | 2 0 | 2 40 | 40 | ,, ,, | 15 × 15 |
| 5 | 2 50 | 3 30 | 40 | Barnet Rocket. | 15 × 15 |
| 6 | 3 40 | 3 45 | 5 | Imperial Ordinary. | 12 × 10 |
| 7 | 4 5 | 4 15 | 10 | ,, Sovereign | 15 × 15 |
| 8 | 4 35 | 4 55 | 20 | Wratten and Wainwright Ordinary. | 12 × 10 |

A ninth plate was taken at 1 o'clock, local time, on which two exposures were made (the driving clock being stopped for two minutes between) for determination of the orientation of the plates.

ires were printed on No. 6 when the plates were put
he night before the eclipse. The exposure given was
a standard candle at the distance of 5 feet.

otographs taken, the two by Burckhalter's method of
er, are failures. The failure is not due to any fault
ut apparently is entirely owing to insufficient expo-
photographed on the plates not extending as far as
ated from previous eclipses. It seems probable that
these would have been quite satisfactory.

hotographs are excellent. The programme of expo-
carefully arranged with the Astronomer Royal before
has resulted in a well graduated series of photographs
h shows the prominences and a small amount of
in which the extension is shown to about 25′ from
The polar plumes and the coronal streamers are
as well as the remarkable detail of the inner corona.
l for special note: (1) the polar streamers round the
are not nearly so extensive as those round its south
remarkable arch in the corona round the large
sition angle 145° (measuring N.E.S.W.). Round this
separate arches are shown, one inside the other, their
·4, and 3′·7 respectively. They have the appearance
s over an eruption.

*Photographs to show Extension of the Corona.*—The
as used in this eclipse exactly as at Ovar to carry a

Abney squares were printed on No. 6 by exposure to a standard candle at a distance of 5 feet for 4 minutes with the Dallmeyer lens, and 8 minutes with the Unar lens. It had been intended to print squares on several plates, but the number of photographs to be dealt with made it necessary to limit work as much as possible the night before the eclipse when the photographic plates were taken from sealed tins and put in their carriers, and after the eclipse it was necessary to finish the developing as soon as possible. Of these photographs Nos. 5, 6, 7, 8 are the most successful. The extension shown with the Abney lens reaches to 66′ from the centre, and with the Unar lens to 77′.

Venus and Mercury and a number of stars are shown on the Unar plates. No. 5 is the best, and shows 7 stars of the Pleiades and 25 others of magnitudes ranging from 4 to 6, which have been identified. Unfortunately, owing to the clouds, stars are not equally well shown all over the plate, and $\delta$ Tauri ($4^m{\cdot}0$) and $\theta$ Tauri ($3^m{\cdot}9$) are not shown; $\gamma$ Tauri ($3^m{\cdot}9$), which is near $\theta$ Tauri, is, however, shown.

It may be concluded that any object appreciably brighter than $4^m{\cdot}0$ within the area covered by the plate (*i.e.* within 15° of the Sun) would have been shown.

### III. *The Spectroscopic Cameras.*

The two spectroscopes used by Captain Hills at the Indian Eclipse of 1898 were kindly lent by him, and were used in Sumatra with the following adjustments:—

| | Spectroscope No. 1. | Spectroscope No. 2. |
|---|---|---|
| Objective | Cooke, achromatic, 4½-in. aperture, 6-ft. 2½-in. focus. | Single quartz lens, 5-in. aperture, 4-ft. 7-in. focus. |
| Collimator and camera lenses | Single quartz lens, 2½-in. aperture, 30-in. focus. | Single quartz lens, 3-in. aperture, 33½-in. focus. |
| Prisms | Two dense flint prisms of 60°, 4½-in. base, 2½-in. height. | Four double quartz prisms of 60° (each prism being composed of two half-prisms of right- and left-handed quartz), 3½-in. base, 2¾-in. height. |
| Slit | 1½ in. by 0·0015 in. | 2 in. by 0·0012 in. |
| Prisms at maximum deviation for | H (λ 4340) | λ 3500. |

The width of the slit of the flint spectroscope was obtained by means of the diffraction images, and that of the quartz was checked in the same manner.

The length of the spectrum of the flint is 3¼ inches from $H_\beta$

3934), and for the quartz 3 inches from λ4000 to
to obtain a greater length of spectrum in focus,
were made, at Mr. Davidson's suggestion, to carry
ies wide, inclined at a suitable angle, instead of one

pes were mounted horizontally, and supplied with
t furnished with a 12-inch flat mirror. The heliostat
the usual manner by means of the attached theo-

*Exposures.*—The two spectroscopes were adjusted to
possible on the Sun's limb simultaneously, and the
posures was the same for both. The cameras were
k movements so that a number of exposures could be
plate. The programme arranged to take—
of short exposures from 10ˢ before to 6ˢ after the
ity for the "flash" spectrum.
rs were then changed, and
re for the spectrum of the corona made from 15ᵐ or
ning of totality, and continued for 5½ minutes—the
t 5ᵐ 50ˢ from the beginning of totality.
rs were again changed, and
10ˢ from the beginning or 10ˢ from the end of totality,
be made for the "flash" at third contact.
l (ii) the image of the Sun was to be brought by the
e heliostat from being nearly tangential to the slit to

to supplement at the two ends of the spectrum, 70 lines being shown between H$\beta$ ($\lambda$ 4861) and $D_3$ ($\lambda$ 5876), and 100 between 3500 and 3296.

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"Total Eclipse of the Sun, 1901 May 18. Preliminary Account of the Observations made at the Royal Alfred Observatory, Pamplemousses, Mauritius." By E. WALTER MAUNDER, F.R.A.S. Received October 24,—Read at Joint Meeting of the Royal and Royal Astronomical Societies, October 31, 1901.

*General Arrangements.*

An expedition from the Royal Observatory to observe the Solar Eclipse of 1901 in the island of Mauritius having been sanctioned by the Admiralty, I was instructed by the Astronomer Royal to proceed to that island, there to act in concert with the Director of the Royal Alfred Observatory, Mr. T. F. Claxton, who had expressed his desire to co-operate in the observation of the eclipse. In accordance with a scheme approved by the Joint Permanent Eclipse Committee of the Royal and Royal Astronomical Societies, I took out with me two instruments belonging to the Royal Observatory, Greenwich, for photographing the corona; the one giving an image of the Moon 2·4 inches in diameter, and intended to secure the general structure of the corona, and the other giving an image 0·3 inch in diameter, and intended to secure the outer coronal streamers. The Joint Permanent Eclipse Committee lent for use in combination with these instruments two cœlostats, the one carrying a mirror of 16 inches diameter, the other one of 12 inches. A third mirror, one of 12 inches diameter, was kindly lent by Mr. Frank McClean, F.R.S. My equipment was completed by the generosity of Mr. John Evershed, F.R.A.S., who very kindly placed his prismatic camera of 2 inches aperture at the disposal of the Astronomer Royal for my use in the eclipse.

I was warmly welcomed in Mauritius by the Director of the Royal Alfred Observatory, Mr. T. F. Claxton, and by his Chief Assistant, Mr. A. Walter. Both identified themselves completely with me in my work, and helped me in every possible way. We therefore combined the instruments which I had brought out with those of the Observatory, and worked with them as though we formed but one party, and as if the instruments were all part of the same equipment.

I was also greatly indebted to Sir Charles Bruce, G.C.M.G., the Governor of the island, and to Sir Graham Bower, K.C.M.G., the officer administrating the Government during the Governor's absence, for the ready hospitality which they extended to me. Through their action, also, my instruments were landed without Customs examina-

nveyed by rail, free of cost, up to Pamplemousses, after the eclipse was over. Free passes on all the land were also issued to me, and to Mrs. Maunder, anied me with a special instrumental equipment of ilitary authorities also rendered great assistance. l H. J. Lyster, R.G.A., gave permission to nine officers of the garrison, who had volunteered for me down to assist in the eclipse observations. Of elped in the unpacking and erection of the instru- Staff-Sergeant R. M. Smith, A.O.C., gave great cleaning, repair, and rating of the several driving- edition was also indebted to the Hon. Hamilton ook the re-shipping of the instruments for the home- o Mr. G. Ireland, who supplied tarpaulins for leton huts erected to shelter the instruments; to de Wilton, Inspector-General of Police, who sent p the Observatory grounds from intrusion on the clipse, and to Mr. D. P. Garrioch, Superintendent of who arranged for the greater part of the provisioning y during their stay at the Observatory.

instruments for the Mauritius expedition were the Royal Observatory on March 6, with the excep- and object-glass of the prismatic camera lent by Mr. .R.A.S., which I took to Marseilles with my personal struments were embarked at the Royal Albert Docks

Pamplemousses, in the low-lying plain which occupies the north of the island of Mauritius. This was about 15 miles to the N.W. of the central line, but as the eclipse was one of long duration, the distance from the central line made but little difference to the length of totality, and several important considerations led to its adoption. First of all, the probabilities of fine weather at the time of the morning when the eclipse would take place, appeared much greater for the low ground in the north of the island, than for the hills in the centre; an anticipation which the event fully justified; for whilst the total phase of the eclipse was observed under favourable conditions at Pamplemousses, it was entirely lost in cloud at Curepipe, on the central line on the high ground in the interior. Next, there were the great advantages offered by the Observatory itself of accurate determination of time, of a site the co-ordinates of which were known, of two instruments on permanent mountings, an equatorial and a photoheliograph, suitable for use in the eclipse, and of two efficient and well constructed dark-rooms for photography.

The observing station was therefore fixed in the Observatory grounds, in Lat. 20° 5′ 39″ S. and Long. $3^h\ 50^m\ 12^s{\cdot}6$ E. according to the "Nautical Almanac," on the authority of the late Dr. C. Meldrum, the former Director.

*Erection and Arrangement of the Instruments.*

The instruments were landed from the "Melbourne" at Port Louis, on April 23, and were conveyed by rail to Pamplemousses, and from thence by road to the Observatory, the same day. The next day they were unpacked, and the positions which they were to occupy were chosen.

The main building of the Observatory is rectangular in form, and nearly but not exactly orientated. Its front or north side is $76\frac{1}{2}$ feet in length, and its breadth is $58\frac{1}{2}$ feet. Opposite the north front and distant from it 160 feet, is the Magnetic Basement, a structure of which only the roof is above the ground, and which is 43 feet square. A broad lawn extends between the two buildings, and the instruments were erected for the most part at the west end of the lawn, so as to command as much of the eastern sky as possible. It was, however, found necessary to cut down a clump of trees on the eastern side of the lawn to a height of 16 feet in order to secure an uninterrupted view of first contact, which would take place when the sun was only 5° high, and this Mr. Claxton accordingly had done.

The instruments were mounted in two divisions. The first division consisted of the Mauritius photoheliograph, which was dismounted from its equatorial stand in a detached dome in the Observatory grounds, and of a rapid rectilinear lens by Dallmeyer, of 4 inches

inches focal length. These two instruments were
ly, the camera of the R.R. lens being placed imme-
photoheliograph tube, and both were supplied with
of a 16-inch mirror mounted on a cœlostat. The
nsisted of the Greenwich coronagraph, and Mr. Ever-
mera. The coronagraph was mounted in a hori-
d the prismatic camera was fixed immediately above
nts being supplied with light by a 12-inch mirror
ostat. Between the two a clock was mounted which
bell close to the camera end of the photoheliograph,
to the 12-inch cœlostat, at every tenth second during
struments were fixed upon boxes filled with stones,
em skeleton huts were formed, each consisting of
les carrying a ridge-pole. Tarpaulins were then
ridge-pole, and pegged down to the ground. When
eeded to be used, one or more of the tarpaulins could
he side upon which it was desired to observe. During
tarpaulins were entirely removed, except one fixed
ond clock, which was left in order to shelter the
he wind.

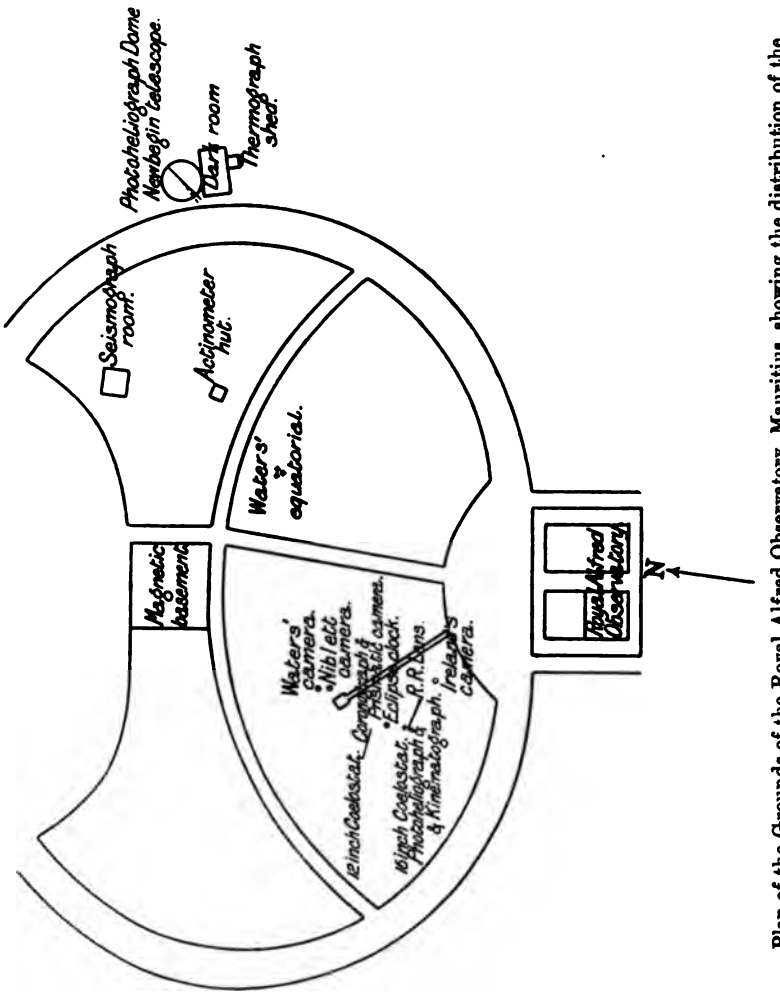
of the instruments relative to the Observatory
wn in the accompanying plan, in which are also
sitions of Mrs. Maunder's instruments, which were
Observatory grounds.

ngement of the instruments was finally completed by

Lance-Corporal Lilley—Recorder to Mr. Maunder.

Bombardier W. Bailey—Moved rack-work of the Evershed prismatic camera.

Colour-Sergeant-Major W. Wade—Exposed at the object-glasses of both the coronagraph and the prismatic camera.




Plan of the Grounds of the Royal Alfred Observatory, Mauritius, showing the distribution of the Instruments during the Total Solar Eclipse of 1901, May 18.

With the 10-seconds eclipse clock :—

Staff-Sergeant R. M. Smith—Time-keeper at 10-second clock.

F. W. Robertson, Lieutenant, R.E.—Recorded times of the 10-second signal-bells.

With the 6-inch equatorial of the Mauritius Observatory:—
F. T. Piggott—Observed with the 6-inch equatorial.
N. V. Olivier—Recorder to Mr. Piggott.

The following was the method of procedure, which was carefully rehearsed many times on May 16 and 17. The observers took their places at their instruments, and Mr. Claxton watched the diminishing arc of the Sun on the ground glass of the photoheliograph, and at 30 seconds before second contact gave the word to "Stand by." At 20 seconds I gave the word to Sergeant-Major Wade to begin the exposure of the plates in the prismatic camera. At 10 seconds, when the arc of sunlight had lessened down to one of 49°, Mr. Claxton called "Ten," the signal to Staff-Sergeant Smith to start the 10-seconds striking eclipse clock, and Staff-Sergeant Smith called the number of the bells as they rang out at every tenth second from this moment until some time after third contact. The exposures at the different cameras were then made at the sound of the bells, and Lieutenant F. W. Robertson, R.E., entered the time of each bell as it rang; a very simple arrangement, which worked smoothly and well, and gave the times of exposure of the different plates very closely.

*The Day of the Eclipse.*—The weather at eclipse time—*i.e.*, from $6^h\ 51^m$ to $9^h\ 5^m$ A.M.—had been by no means promising for the first three weeks after landing, but had tended to improve later. The morning of May 18 was the first upon which the Sun had been entirely free from cloud at the time of totality, $7^h\ 53^m$ A.M., and even on that morning first contact was lost by the interposition of a dense bank of cloud, which came up from the east soon after sunrise and overtook the Sun. It passed away in a few minutes, and the first photograph of the partial phase was taken at 16 minutes after the predicted time for first contact. Light scud continued to pass over the Sun for about 40 minutes more, but got thinner and lighter as totality drew on, and about $2\frac{1}{2}$ or 3 minutes before second contact the entire eastern half of the sky was free from cloud, and remained so until after fourth contact. But though the sky was thus apparently clear there was evidently much moisture in the air, since at Quatre Bornes, 13 miles to the south-west, the total phase was observed in a smart drizzle of fine rain; and at Curepipe, 16 miles to the south, it was entirely lost by thick cloud. The images also, as seen upon the ground glasses of the photoheliograph and coronagraph, were very unsteady, the Sun's limb "boiling" excessively. This "boiling" effect would seem to have been less noticeable in the 6-inch equatorial mounted in a dome on the roof of the Observatory main building, and in the Newbegin telescope brought by Mrs. Maunder and mounted in the photoheliograph dome of the Observatory, and which were therefore at a considerable elevation than in the instruments fed by the two

cœlostats which were necessarily quite close to the ground. The position of the latter, in the open air and placed horizontally, would render them more exposed to the effect of ground currents than the two other telescopes would be, pointing upwards at an angle of 19° and within domes.

The darkness during totality to the observers out in the open air was not great, the general illumination being considerably greater than at the full Moon. Five observers, noting the twilight illumination in the evening after the eclipse, considered it equal to that of mid-totality at the following local times:—

| | h. | m. | |
|---|---|---|---|
| Mrs. Claxton | 5 | 58 | P.M. |
| Mrs. Maunder | 5 | 57 | |
| Mr. Claxton | 5 | 58 | |
| Mr. Hall | 5 | 58 | |
| Mr. Maunder | 5 | 57 | |

corresponding in the mean to 31 minutes after geometrical sunset, or to a position of the Sun, neglecting refraction, of 6° 53′ below the horizon.

But the observers in the equatorial and photoheliograph domes found it very dark during totality. A sudden gust of wind came from the N.E. at the moment of second contact and blew out the observer's candle in the equatorial dome. The recorder here, Mr. Olivier, found it quite impossible to read his chronometer or to write in the darkness, and hence Mr. Piggott's determination of the times of the second and third contacts were wholly lost.

Venus and Mercury were both very brilliant, side by side, some 5° below the Sun, whilst Jupiter and Saturn were prominent in the western sky. No search was made for other celestial objects.

*Times of the Contacts.*—The following determinations were made of the times of the three last contacts. As already stated, the first contact was lost through cloud:—

| bserver | T. F. Claxton. | E. W. Maunder. | A. Walter. | Capt. Robertson. |
|---|---|---|---|---|
| lace | R. Alfred Obs. | R. Alfred Obs. | R. Alfred Obs. | ss. "Ugina." |
| nstrument | Photoheliograph | Coronagraph. | Newbegin telesc. | Navy telescope. |
| perture | 4 in. | 4 in. | 4¼ in. | 2 in. |
| hronometer | Kullberg 3400. | H. White 1424. | Webster 925 | |
| rror of chronometer | $1^m\ 0^s{\cdot}4$ f. | $3^h\ 53^m\ 47^s{\cdot}3$ s. | $2^m\ 58^s$ s. | |
| bserved times— | | | | |
| Second contact. | .. | 3 57 52·2 | $7^h\ 48^m\ 43^s$ | |
| Third contact.. | .. | 4 1 25·1 | 7 52 15 | |
| Fourth contact | $9^h\ 5^m\ 43^s{\cdot}0$ | 5 10 55·1 | | |
| rue local times— | | | | |
| Second contact. | .. | 7 51 39·5 | 7 51 41 | $7^h\ 51^m\ 38^s$ |
| Third contact.. | .. | 7 55 12·4 | 7 55 13 | 7 55 12 |
| Fourth contact | 9 4 42·6 | 9 4 42·4 | | |

Captain Robertson was not present at the Royal Alfred Observatory, but observed the eclipse from the deck of his ship, ss. "Ugina," of the British India Steam Navigation Company, in Port Louis harbour, 6½ miles S.W. by W. of the Observatory.

An accident prevented Mr. Claxton from observing the second and third contacts. Mr. Claxton and myself watched the contacts on the ground-glass screens of our respective cameras.

*Times of the 10-second Bells.*—The times of the 10-second bells of the eclipse clock—which was one of the clocks used by the late Sir G. B. Airy, K.C.B., in the Harton Colliery experiment—were recorded by Lieutenant F. W. Robertson, R.E., with the chronometer Kullberg 3400, that chronometer being $1^m\ 0^s{\cdot}4$ fast.

| No. of Bell. | Observed time. | True local time. |
|---|---|---|
| | h. m. s. | h. m. s. |
| 1 | 7 52 42·3 | 7 51 41·9 |
| 2 | 52·3 | 51·9 |
| 3 | 53 2·3 | 52 1·9 |
| 4 | 12·2 | 11·8 |
| 5 | 22·1 | 21·7 |
| 6 | 32·1 | 31·7 |
| 7 | 41·9 | 41·5 |
| 8 | 51·9 | 51·5 |
| 9 | 54 1·8 | 53 1·4 |
| 10 | 11·8 | 11·4 |
| 11 | 21·8 | 21·4 |
| 12 | 31·7 | 31·3 |
| 13 | 41·8 | 41·4 |
| 14 | 51·8 | 51·4 |
| 15 | 55 1·8 | 54 1·4 |
| 16 | 11·8 | 11·4 |
| 17 | 21·7 | 21·3 |
| 18 | 31·7 | 31·3 |
| 19 | 41·7 | 41·3 |
| 20 | 51·8 | 51·4 |
| 21 | 56 1·6 | 55 1·2 |
| 22 | 11·6 | 11·2 |
| 23 | 21·6 | 21·2 |
| 24 | 31·6 | 31·2 |

Staff-Sergeant R. M. Smith called out the numbers of the bells as each rang.

*Photographs of the Corona.*—These were taken on three different scales; the first on a scale of 8 inches to the Moon's diameter, to show the prominences and lowest corona; the second on a scale of 2·4 inches, to show the general structure of the corona; the third on a scale of 0·3 inch, to show the coronal streamers to the greatest possible extension. The aperture employed in each case was the same, viz., 4 inches, and the light-gathering powers on the plate of the three instruments were nearly in the proportion of 1, 11, and 700.

(1.) *Photographs on the 8-inch Scale.*

These were taken by Mr. T. F. Claxton with the photoheliograph of the Royal Alfred Observatory, Mauritius, the object-glass of which is 4 inches in aperture and 5 feet in focal length. It gives an image of the Sun nearly 8 inches in diameter, being fitted with a secondary magnifier, enlarging the image in the primary focus $13\frac{3}{4}$ times. The total length of the photoheliograph was $9\frac{1}{2}$ feet; its equivalent focal length 69 feet. The camera was constructed to carry plates 10 inches square, and it was proposed to expose six plates during totality for photographs of the corona, and as many as possible during the partial phase for determination of the Moon's place, and of the relative diameters of the Sun and Moon. Only three plates were exposed during totality, the handle of the shutter of the fourth plate-carrier breaking short off when the shutter was opened. The plate-carrier was thus locked in the camera, and it was not possible to release it until the total phase was over. The three plates taken were exposed as below, the exposures being given by Mr. Rowden at the object-glass of the instrument at the sound of the signal bells.

| No. | From | To | Duration of exposure. | Plate. |
|---|---|---|---|---|
| | | | sec. | |
| 1 | Bell 3 | Bell 5 | 20 | Edwards' Medium. |
| 2 | ,, 6 | ,, 8 | 20 | Imperial Ordinary. |
| 3 | ,, 8 | ,, 11 | 20 | ,, Special Rapid. |

After totality the clock of the cœlostat was stopped, and three photographs of the Sun were taken on the same plate for orientation. The true local times of the first and last of these were :—

| h. | m. | s. |
|---|---|---|
| 8 | 15 | 20·1 |
| 8 | 16 | 5·2 |

The time of the second exposure was not recorded. The plate was an "ordinary lantern" by Cadett and Neale. The aperture of the photoheliograph was reduced to $1\frac{1}{2}$ inches, and the exposure was given by the drop-slit in the primary focus.

Two sets of "Abney squares" were printed upon No. 3 on June 13, before the plate was developed. Both sets were printed by the light of a Sugg's Standard candle; the one being exposed for 4 seconds, the other for 64 seconds, the candle being at a distance of 10 feet in both cases.

The corona is seen only on the E. side of the Sun, as the image is

somewhat out of the centre of the plate in all three of the photographs; and owing partly to shake in the instrument, and partly to the excessive atmospheric disturbance, which under the high magnification employed was very apparent, the definition is poor in each case.

No. 1. The corona is shown to a height of about 1 minute of arc. The image is faint.

No. 2. The corona is shown to a height of about 3 minutes of arc. The image is fairly dense.

No. 3. The corona is shown to a height of about 2 minutes of arc. The image is faint and flat.

The Mauritius photoheliograph was focussed by repeated photographs of the Sun, taken during the fortnight preceding the eclipse.

(2.) *Photographs on the 2·4-inch Scale.*

These were taken with the object-glass of the Dallmeyer photoheliograph No. 5, belonging to the Royal Observatory, Greenwich —and which, like that of the Mauritius photoheliograph, had an aperture of 4 inches and a focal length of 5 feet—used in connection with a concave telephoto lens by Dallmeyer, of 3 inches aperture and 12 inches focal length. The instrument thus constructed has been referred to for convenience as the "Greenwich coronagraph," and was about 7½ feet in actual length, with an equivalent focal length of nearly 21 feet. It was furnished with ten plate-holders to take 12 by 10-inch plates, and it was proposed to take seven photographs during totality.

These photographs were taken by myself, Colour-Sergeant-Major Wade exposing at the object-glass of the instrument by the signal bells as follows:—

| No. | From | To | Duration of exposure. | Plate. |
|---|---|---|---|---|
| | | | secs. | |
| 1 | Bell 2 | Bell 3 | 10 | Wratten and Wainwright Instantaneous. |
| 2 | „ 4 | „ 6 | 20 | Ilford Empress. |
| 3 | „ 7 | „ 11 | 40 | Imperial Special Rapid. |
| 4 | „ 12 | „ 15 | 30 | „ Sovereign. |
| 5 | „ 16 | „ 18 | 20 | „ Fine Grain Ordinary. |
| 6 | „ 19 | „ 20 | 10 | „ Special Rapid. |
| 7 | „ 21 | — | 4 | „ Ordinary. |

After the ground glass had been inserted for the observation of third contact, and had been removed again, the aperture was diminished to half an inch, and the clock of the coelostat stopped and three photo-

graphs were taken of the Sun, on the same plate for orientation. The plate was an Imperial Fine Grain Ordinary and the exposure was as quick as could possibly be given by uncovering and covering the object-glass by hand. The true local times of the three exposures were :—

| h. | m. | s. |
|---|---|---|
| 7 | 58 | 39·3 |
| 7 | 58 | 57·3 |
| 7 | 59 | 17·3 |

A ninth plate, a Wratten and Wainwright Instantaneous plate, was exposed with the same aperture and exposure at $8^h\ 0^m\ 17^s{\cdot}3$. The plate in the tenth plate-holder was not used.

Two sets of "Abney squares" were printed upon No. 4 on June 13, before the plate was developed. Both sets were printed by the light of a Sugg's Standard candle, at 5 feet distance; the one being exposed for 15 seconds, and the other for 4 minutes.

No. 1 is a clean and fairly dense negative, showing well the polar rays and the structure of the lower corona, especially in the east equatorial wing. The west wing shows less detail. The corona is traceable to a distance of 15 or 16 minutes from the limb of the Moon in the S.E. ray.

No. 2 is a clear thin negative showing much about the same detail as No. 1.

No. 3 is a thin negative but shows a considerable extension of the great S.E. and N.E. rays and a good deal of detail in their lower regions.

No. 4 is a dense negative showing the greatest degree of extension in the coronal streamers of any of the series. In the case of the two chief rays, the corona can be traced to a distance of nearly half a degree from the Moon's limb.

No. 5 shows the lower corona well up to 5 or 6 minutes from the Moon's limb.

No. 6 is partly spoiled by fog, and only the lower corona is seen up to about 3 minutes.

No. 7 is a faint and delicate negative showing the chromosphere, prominences, and the lower corona up to a distance of about 3 minutes from the limb of the Moon.

Two methods were employed to focus the Greenwich coronagraph; the first being the method described by the Astronomer Royal in his Reports of the Eclipse Expeditions of 1896, 1898, and 1900,* an image of an object (gauze net in the plane of the plate) being photographed by reflection normally from the plane mirror of the cœlostat. The second method was by photographing Arcturus, the image of which was allowed to trail across the plate.

* 'Roy. Soc. Proc.,' vol. 64, p. 8; and 'Monthly Notices, R.A.S.,' vol. 57, p. 105, and vol. 60, p. 397.

(3.) *Photographs on the* 0·3*-inch Scale.*

These were taken by Professor T. A. Pope, of the Royal College, Mauritius, with a Dallmeyer rapid rectilinear lens of 4 inches aperture, and 32 inches focal length, Mr. E. G. Rowden exposing at the object-glass at the same time as he exposed for the Mauritius photoheliograph, which was mounted immediately below it. Six plate-carriers were provided for this instrument, and six photographs of the corona were secured.

| No. | From | To | Duration of exposure. | Plate. |
|---|---|---|---|---|
| | | | sec. | |
| 1 | Bell 3 | Bell 5 | 20 | Imperial Process. |
| 2 | „ 6 | „ 8 | 20 | „ Ordinary. |
| 3 | „ 9 | „ 11 | 20 | „ Special Rapid. |
| 4 | „ 12 | „ 14 | 20 | Ilford Empress. |
| 5 | „ 15 | „ 17 | 20 | Wratten and Wainwright Instantaneous. |
| 6 | „ 18 | „ 20 | 20 | Imperial Fine Grain Ordinary. |

The plates used were 16 cm. square, and the Sun was placed a little to the west of the centre of the field, so that Venus and Mercury might be included in the photographs. As they are well shown on all the plates, there was no need for any other mode of orientation, and no special photographs were taken for that purpose. Nor were the "Abney squares" printed on any of the plates with this instrument.

No. 1. A good clear negative. On the west side of the corona four straight rays are seen, the two longest extending about $1\frac{1}{4}^{\circ}$ from the Moon's limb. On the east two chief rays are seen, forming the edges of the great east equatorial wing of the corona. A fainter ray runs nearly parallel to the great N.E. ray. The rays on the E. are traceable to about 1° from the Moon's limb.

No. 2. Neither so dense nor so clear as No. 1, nor can the rays be traced quite so far upon it.

No. 3. The sky glare has come up on this plate, which in consequence shows less than Nos. 1 and 2.

No. 4. Definition poor.

No. 5. Definition poor.

No. 6. Very dense image; the rays on the west can be traced to more than 2° from the Moon's limb.

The Dallmeyer R.R. lens was focussed by repeated photographs of star fields, especially of the field of the Southern Cross.

*Development of the* Photographs.—Owing to my having been taken ill on May 21 with a severe attack of malarial fever, the work of

developing the photographs was almost entirely carried out by Mr. Walter and by Mrs. Maunder, to whom the expedition is therefore greatly indebted for the results obtained. The weather being hot and damp, much difficulty was experienced with the different plates tested by way of experiment before the day of the eclipse. Finally the following developer was adopted and found to work well. In spite of its excessive dilution, it was found that fog resulted if its strength was materially increased.

Solution A.

| | |
|---|---|
| Metol ..... | 40 grains. |
| Hydroquinone ..... | 50 „ |
| Sulphite of soda ..... | 120 „ |
| Bromide potassium ..... | 15 „ |
| Water ..... | 20 ounces. |

Solution B.

| | |
|---|---|
| Caustic soda ..... | 100 grains. |
| Water ..... | 20 ounces. |

For development half an ounce was taken of each stock solution and made up with water to 30 ounces, 15 drops of a 10 per cent. solution of bromide of potassium being added. During development this solution was strengthened by the gradual addition to it of a solution composed of 1 ounce of each of the two stock solutions made up with water to 10 ounces. But the stronger solution was seldom added to the weaker in a greater proportion than 1 to 15. The average time of development was 75 minutes.

*Photographs of the Partial Phase.*—These were taken with the photoheliograph of the Royal Alfred Observatory, Mauritius, already described. The aperture for this purpose was reduced to 1½ inches, and the exposure given by the drop-slit in the primary focus. Mr. T. F. Claxton made the exposures, and called the times by Kullberg 3400 to Bombardier Cox, who entered them. There being only three plate-carriers available for this work, Mr. C. Garrioch remained in the dark room to change the plates, and Bombardier Truman ran to and fro with them. The plates used were Cadett and Neale's ordinary lantern plates. The times of exposure were as follows :—

Before Totality.

| No. | Observed times. h. | m. | s. | True local times. h. | m. | s. |
|---|---|---|---|---|---|---|
| 1 ..... | 7 | 8 | 19·8 | 7 | 7 | 19·4 |
| 2 ..... | 7 | 10 | 19·8 | 7 | 9 | 19·4 |
| 3 ..... | 7 | 14 | 5·3 | 7 | 13 | 4·9 |
| 4 ..... | 7 | 18 | 1·3 | 7 | 17 | 0·9 |
| 5 ..... | 7 | 22 | 46·3 | 7 | 21 | 45·9 |
| 6 ..... | 7 | 28 | 47·3 | 7 | 27 | 46·9 |
| 7 ..... | 7 | 31 | 7·8 | 7 | 30 | 7·4 |
| 8 ..... | 7 | 35 | 6·2 | 7 | 34 | 5·8 |
| 9 ..... | 7 | 38 | 47·3 | 7 | 37 | 46·9 |
| 10 ..... | 7 | 42 | 43·0 | 7 | 41 | 42·6 |
| 11 ..... | 7 | 44 | 32·4 | 7 | 43 | 32·0 |

After Totality.

| | | | | | | |
|---|---|---|---|---|---|---|
| 12 ..... | 8 | 2 | 48·8 | 8 | 1 | 48·4 |
| 13 ..... | 8 | 3 | 43·3 | 8 | 2 | 42·9 |
| 14 ..... | 8 | 11 | 44·5 | 8 | 10 | 44·1 |
| 15 ..... | 8 | 12 | 41·0 | 8 | 11 | 40·6 |

Plate 16 had three exposures made upon it, the clock of the coelostat being stopped in order to give the means for determining the orientation of the plates.

| No. | Observed times. h. | m. | s. | True local times. h. | m. | s. |
|---|---|---|---|---|---|---|
| 17 ..... | 8 | 19 | 40·0 | 8 | 18 | 39·6 |
| 18 ..... | 8 | 22 | 34·3 | 8 | 21 | 33·9 |
| 19 ..... | 8 | 24 | 25·7 | 8 | 23 | 25·3 |
| 20 ..... | 8 | 26 | 44·3 | 8 | 25 | 43·9 |
| 21 ..... | 8 | 31 | 28·6 | 8 | 30 | 28·2 |
| 22 ..... | 8 | 32 | 33·2 | 8 | 31 | 32·8 |
| 23 ..... | 8 | 34 | 40·5 | 8 | 33 | 40·1 |
| 24 ..... | 8 | 36 | 24·5 | 8 | 35 | 24·1 |
| 25 ..... | 8 | 39 | 56·3 | 8 | 38 | 55·9 |
| 26 ..... | 8 | 42 | 7·5 | 8 | 41 | 7·1 |
| 27 ..... | 8 | 45 | 13·2 | 8 | 44 | 12·8 |
| 28 ..... | 8 | 48 | 15·4 | 8 | 47 | 15·0 |
| 29 ..... | 8 | 50 | 33·7 | 8 | 49 | 33·3 |
| 30 ..... | 8 | 53 | 8·2 | 8 | 52 | 7·8 |
| 31 ..... | 8 | 54 | 5·0 | 8 | 53 | 4·6 |
| 32 ..... | 8 | 59 | 50·2 | 8 | 58 | 49·8 |

The Director of the Royal Alfred Observatory has presented to the Astronomer Royal the photographs of the eclipse which he took with

the Observatory photoheliograph, both the photographs which he took of the corona during totality and the above photographs of the partial phase. The former I myself brought home to the Royal Observatory, Greenwich; the latter will be sent at the first available opportunity.

I took no observations myself of temperature during the eclipse, the Director of the Royal Alfred Observatory having made arrangements for full meteorological observations being taken both at the Observatory and at several other stations, not only in Mauritius, but also on other islands in the Indian Ocean.

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"Preliminary Note on Observations of the Total Solar Eclipse of 1901 May 18, made at Pamplemousses, Mauritius." By (Mrs.) A. S. D. MAUNDER. Received October 23,—Read at Joint Meeting of the Royal and Royal Astronomical Societies, October 31, 1901.

Having observed successfully the eclipses of 1898 January 22, in India, and 1900 May 28, in Algiers, and my husband having been sent to Mauritius as the representative of the Royal Observatory, Greenwich, to observe the eclipse of May 18 last, I determined to accompany him, and to take with me the instruments which we had used in 1900. By the great kindness of Mr. G. J. Newbegin, F.R.A.S., I was also furnished with a 4¼-inch Cooke photo-visual telescope of 71 inches focus.

As my husband fixed his observing station at the Royal Alfred Observatory, Pamplemousses, and as the Director, Mr. Claxton, gave me every facility, I set up my instruments in the Observatory grounds. The Newbegin telescope was mounted upon the equatorial stand of the photoheliograph which was left vacant, the Mauritius photoheliograph having been dismounted in order that it might be used in connection with the 16-inch cœlostat of the official Greenwich Expedition. The photoheliograph dome stands on the east of the Observatory grounds, and about 150 feet to the west of the dome I set up the Waters equatorial lent to my husband by the Royal Astronomical Society, which I used to carry two little cameras, each with a 1½-inch Dallmeyer Stigmatic lens. About 105 feet further west the camera belonging to the Waters telescope was firmly fixed, pointing directly to the Sun, and by its side the Niblett lens belonging to the British Astronomical Association, a photographic lens 4 inches in diameter, and of 34 inches focus. This was likewise fixed rigidly. Mr. Nevil Maskelyne, F.R.A.S., also lent me his kinematograph, and this was mounted a few feet further south. The management of these instruments during the eclipse was very kindly undertaken by several friends, and I was

by three non-commissioned officers who had volun-
in the eclipse observations. The entire party was
ws :—

*Personnel.*

: Newbegin photo-visual telescope, 71 inches focus.
H. Thorne : Recorder to Mr. Walker.
Maunder : Dallmeyer Stigmatic lens twin camera,

. Tyson : Recorder to Mrs. Maunder.
l A. Balguè : Waters camera, 8 feet equivalent focus.
land : Kinematograph. The kinematograph gave no
earing across before totality was reached.
brought a camera of about 2 feet focus, which was
ationary camera, and six exposures were made with it
anning.)
rief description of the photographs obtained :

. *The Dallmeyer Stigmatic Twin Camera.*

re each $1\frac{1}{2}$ inches aperture, 9 inches focus, and give a
in diameter on a plate 16 cm. square. I procured one
n 1897, on account of its great field, in order to photo-
Way, and it being the only photographic lens I then
it to India in 1898. Exposures of 20 seconds made
corona of that year, recorded the coronal extensions

sky glare has come up, and the extensions are not so considerable as in the former case.

No. 3.—From 170 seconds to 190 seconds. Exposure 20 seconds. Sandell Triple-coated plate.

The image of the corona is fairly dense, but the sky glare has not come up so much as in the previous cases, and it shows as great extension as No. 1.

No. 4.—From 170 seconds to 190 seconds. Exposure 20 seconds. Imperial Special Rapid plate.

This is a weak image, and has no points to recommend it.

(Nos. 3 and 4 have a double image on them, due probably to the cameras not having settled down after the plate-carriers were changed.)

2. *The Niblett Lens.*

This lens is of 4 inches aperture and 34 inches focus, fitted with a revolving drum carrying 5-inch by 4-inch plates.

No. 1.—Exposed at second contact. Exposure about $\frac{1}{4}$ second. Imperial Fine Grain plate.

This photograph was taken at second contact, and several "beads" of sunlight are seen. Nevertheless, not only is there a great deal of detail to be seen in the middle corona, but on the west side a coronal ray can be traced to two lunar radii, and on the east side to a somewhat greater distance. The image is a fairly dense one. The image is not large enough, nor was the exposure sufficiently short to show any detail in the prominences or chromosphere, but the polar rays and the "combing out" of the equatorial wings are well seen.

No. 2.—Exposed at 40 seconds. Exposure about $\frac{1}{4}$ second. Imperial Ordinary plate.

A fairly dense image, showing the polar rays and middle corona well.

No. 3.—Exposed at 80 seconds. Exposure about $\frac{1}{4}$ second. Imperial Special Rapid plate.

The image is not so dense as in the previous cases, but the coronal rays can be traced to a greater distance, as can also the polar rays.

No. 4.—Exposed at 120 seconds. Exposure about $\frac{1}{4}$ second. Imperial Special Rapid plate.

A weak faint image, under-developed. No detail shown.

No. 5.—Exposed at 160 seconds. Exposure about $\frac{1}{4}$ second Imperial Ordinary plate.

Under developed, only the chromospheric ring seen.

ɔd at 200 seconds. Exposure about $\frac{1}{4}$ second. rial Fine Grain plate.

not very dense, showing the middle corona and

3. *The Newbegin Telescope.*

Cooke photo-visual objective of $4\frac{1}{4}$ inches aperture ıs. The photographs were taken on quarter plates. ɔeedingly fine series of fourteen, taken on different l with differing exposures. They bear magnification ıit we have yet tried, namely, to one giving 4 inches ɔter. Every photograph in this series was successful.

ɐd 7 seconds after commencement of totality. sure instantaneous. Plate, Lumière Orthochromatic, s A.

ry dense negative, and shows the prominences on the un, and the very complicated structure of the corona

From the large prominence on the Sun's east equa- ıry marked and irregular black rifts or streaks cross and seem to broaden as they get further away from ar single streak leaves the Sun's surface to the south inence in the south-east.

No. 5.—Exposed 1 minute after commencement of totality. Exposure 8 seconds. Plate, Imperial Fine Grain Ordinary.

A negative very similar to No. 4.

No. 6.—Exposed at 77 seconds after commencement of totality. Exposure 10 seconds. Plate, Imperial Fine Grain Ordinary.

No. 7.—Exposed at 94 seconds after totality. Exposure 6 seconds. Plate, Imperial Ordinary.

This negative is perhaps not so well defined as the others.

No. 8.—Exposed at 107 seconds after totality. Exposure 6 seconds. Plate, Imperial Ordinary.

This negative is not very dense, but the corona is very large, and it shows a greater extension of the coronal rays than any of the previous ones.

No. 9.—Exposed at 126 seconds after totality. Exposure 10 seconds. Plate, Imperial Fine Grain Ordinary.

No. 10.—Exposed at 144 seconds after totality. Exposure 8 seconds. Plate, Imperial Fine Grain Ordinary.

No. 11.—Exposed at 162 seconds after totality. Exposure 6 seconds. Plate, Imperial Fine Grain Ordinary.

On this negative it is very clearly seen that the bulbous curves at the base of the great north-east wing are laid over and across other coronal curves in the background.

No. 12.—Exposed at 176 seconds after totality. Exposure 4 seconds. Plate, Imperial Fine Grain Ordinary.

This photograph shows perhaps best the corona in the south-west region. Here there seem to be a number of synclinal groups, which give the impression of not being all in the plane of the photograph, as usually appears to be the case in coronal negatives, but in different planes.

No. 13.—Exposed at 191 seconds after totality. Exposure 2 seconds. Plate, Imperial Fine Grain Ordinary.

The corona is here very restricted. In the south-west region the exposure does not seem to have been sufficient to bring up all the synclinal groups, and in consequence the south polar rays have the appearance of encroaching on this side.

No. 14.—Exposed at 202 seconds after the commencement of totality. Exposure instantaneous. Plate, Lumière Orthochromatic, Series A.

This negative is fainter then any of the others, but shows well the detail and prominence in the south-west region of the corona.

4. *The Waters Camera.*

This is a Dallmeyer portrait combination of 2 inches aperture and 8 feet equivalent focus, a Dallmeyer telephoto lens being used as a negative enlarger. The photographs were taken on half plates. The enlargement is rather too great for detail of any importance to be shown, and there is therefore no need to describe them in detail. Exposures of about a quarter of a second were given in all cases.

No. 1.—Exposed at second contact. Plate, Imperial Special Rapid.
No. 2.—Exposed at 40 seconds. Plate, Imperial Special Rapid.
No. 3.—Exposed at 80 seconds. Plate, Imperial Flashlight.
No. 4.—Exposed at 120 seconds. Plate, Imperial Flashlight.
No. 5.—Exposed at 160 seconds. Plate, Imperial Flashlight.
No. 6.—Exposed at 200 seconds. Plate, Imperial Special Rapid.

5. *The Pinhole Camera.*

This was a camera with pinhole aperture of $\frac{1}{32}$ of an inch, and the plate was placed at a distance of 30 inches. The plate was exposed immediately before second contact, and closed immediately after third. A small arc of sunlight is thus seen both on the east and west limbs of the Moon. A coronal ring, about 4 minutes in greatest height, is seen connecting these arcs. The little photograph has of course no scientific value, but as being the only instance of a photograph of the corona taken with a pinhole, it may rank as a curiosity. The ratio of aperture to focal length was as 1 to 960, and the exposure given to the plate would correspond to one of $\frac{1}{15}$th of a second, as given with the Newbegin. The plate used was an Imperial Special Rapid.

6. *Photographs of the Landscape.*

At my request M. Alexander Rambert, a professional photographer of Mauritius, took a series of photographs of the landscape during the coming on and passing off of the shadow. The same exposure was given in every instance, the plates were all from the same batch, and they were developed at one and the same time, in the same bath and for the same length of time. The exposures were made at regular intervals of 5 minutes, the first being taken $27\frac{1}{2}$ minutes before mid-totality, the last $27\frac{1}{2}$ minutes after. A comparison of the plates taken before totality with those taken at corresponding times after, shows a slight but appreciable increase in density in the later plates as compared with the earlier, but perhaps not more than would be accounted for by the increase in altitude of the Sun.



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# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

APPENDIX TO VOL. LXII.

[*From Proceedings of the Royal Society, Vols. LXIX and LXX.*]

With indication of the original pagination.

**No. 2.**

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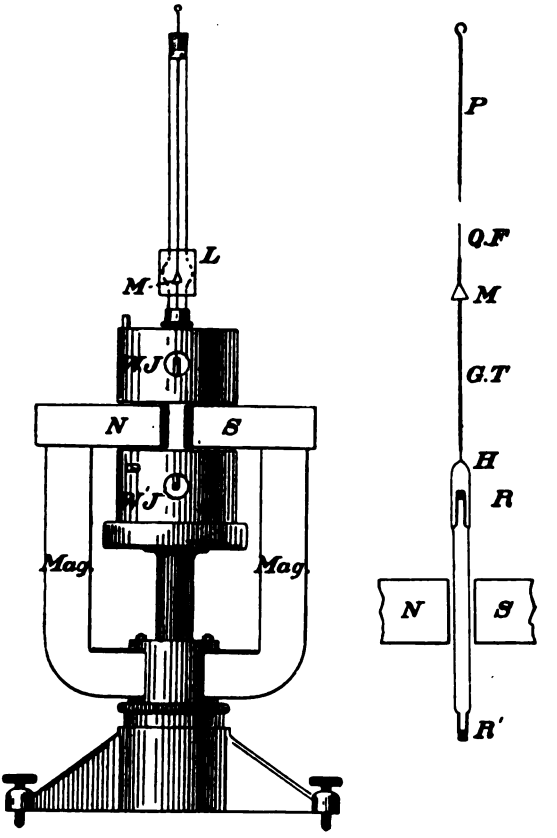
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e Temperature of the Sun." By W. E. WILSON, Received December 5,—Read December 12, 1901.

894, Dr. G.Johnstone Stoney communicated to the oir by myself and Mr. P. L. Gray, entitled "Experiations on the Effective Temperature of the Sun," which in the 'Phil. Trans.,' A, vol. 185 (1894). In these he method we adopted was as follows:—A beam of ent horizontally into the laboratory by means of a nirror heliostat. The mirror was an optical plane lass, and the beam was directed into one aperture (A)

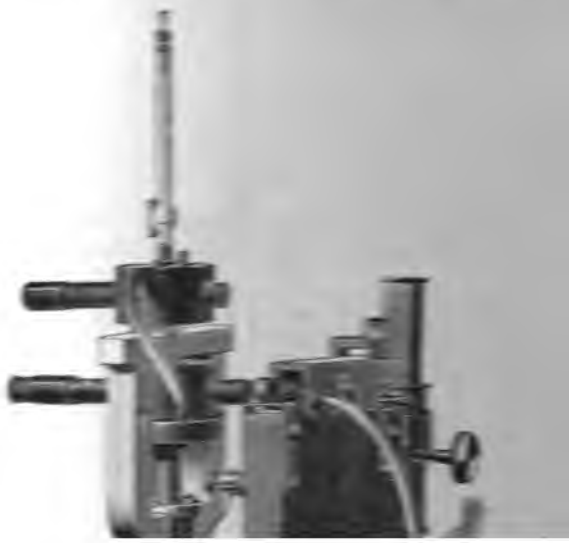
For the details of the apparatus and the complete method of reduction of the observations, the original memoir in the 'Phil. Trans.' may be referred to.




In order to protect the incandescent strip from draughts of air it was covered with a water-jacket of gilded brass. This was provided with a circular hole in one of its longer sides, through which its radiation could reach the aperture of the radio-micrometer. The internal walls of this water-jacket being highly polished, it has occurred to me, since the publication of the memoir referred to, that possibly some of the radiation from distant parts of the platinum strip may have been reflected backwards and forwards from the polished walls and the strip itself, ultimately escaping through the aperture and reaching the radio-micrometer, thus increasing the amount of radiation which should have reached it directly from the strip alone.

In order to test this surmise I first took a number of readings at known temperatures with the walls of the water-jacket polished as

worked in vacuo of the walls well, and found the electric running from the aperture was then steadily also possible that changes in the condition of the electric strip may affect its sensitive, and so that it whether it is possible to determine with any degree of a sensitivity of bright platinum is, relatively to long



radiation from such an enclosure confirms in a remarkable manner Stefan's law of radiation, viz., $R = aT^4$.* Since therefore the results of several independent investigations corroborate this law, I have felt justified in applying it to the results of my observations.

On consideration it seemed that the most convenient form of radiator would be a long tube closed at one end, and uniformly heated in a gas furnace. Accordingly a porcelain tube, 2 feet in length and 1 inch internal diameter, was fitted into a Fletcher gas-tube furnace. This was afterwards changed for an iron tube, which was employed in the observations on September 30th, given below.

A plug of asbestos was inserted in the tube at about 10 inches from the end farthest from the radio-micrometer, and resting against this plug was the end of a Callendar platinum-resistance thermometer. This was connected with one of Professor Callendar's electric recorders, so that during an experiment the temperature of the tube was registered continuously on the paper wrapped round the drum of the instrument. In front of the open end of the tube, and between it and the radio-micrometer, was placed a large brass water-screen, through which a copious supply of water passed. In front of the aperture (B) of the radio-micrometer this screen was provided with a rectangular aperture. One side of this aperture was formed by a slide moved by a micrometer screw reading to 0·01 mm. By this means the area of this aperture at any time could be measured with precision. Its fixed sides were 5 mm. apart, and as the movable side had a range of 5 mm., the maximum area of the aperture was 25 sq. mm. The distance ($d$) of this aperture from the surface of the thermo couple was 66·3 mm.

To make an observation the tube was heated to as high a temperature as the furnace was capable of, and when a steady temperature had been obtained, the amount of radiant heat coming from the interior of the hot tube and passing into the aperture (B) of the radio-micrometer was adjusted by the micrometer screw until a balance was obtained with the radiation coming from the Sun through the aperture (A).

If $\rho$ is the angular semi-diameter of the sun, its radiation outside of our atmosphere is $K.\pi \sin^2 \rho$, where K is a constant depending on the sun's temperature.

Again, if $\alpha$ be the height of the slit through which the radiation from the hot tube reaches the radio-micrometer, and $\beta$ its width, the radiation may with sufficient accuracy be expressed by $K\alpha\beta/d^2$. Assuming Stefan's law, the radiation of the sun outside our atmosphere is $a\theta^4\pi \sin^2 \rho$, $\theta$ being the effective temperature of the sun.

* Stefan, 'Sitzber. d. k. Akad. zu Wien,' vol. 79, 1879 (Abth. 2), p. 391; Boltzmann, 'Wied. Ann.,' vol. 22, 1884; M. Planck, 'Drude Ann.,' vol. 1, No. 1, 1900; Paschen, 'Wied. Ann.,' vols. 58, 60, 1896, 1897; Lummer and Pringsheim, 'Wied. Ann.,' vol. 63, 395, 1897.

transmitted is $p$, therefore the radiation before heliostat is $\frac{\sigma p \theta^4}{100} \pi \sin^2 \rho$.



We need not inquire what is the absorptive power of the thermo-junction, provided that we are justified in assuming that lamp-blacked surfaces absorb the radiation from the hot tube as freely as that from the sun, or that the constants in these expressions (1) and (2) for the radiation may be taken to be equal.

On balancing, these expressions must be equal, and therefore

$$\frac{pq\theta^4}{(100)^2} \cdot \pi \sin^2\rho = (T^4 - T_0^4)\frac{\alpha\beta}{d^2}$$

$$= T^4\left(1 - \left(\frac{T_0}{T}\right)^4\right)\frac{\alpha\beta}{d^2} \quad \ldots\ldots\ldots\ldots (3).$$

But $\left(\frac{T_0}{T}\right)^4$ may be neglected, hence we have finally

$$\theta^4 = \frac{\alpha}{\pi d^2}\ \frac{\beta}{\sin^2\rho}\ \frac{100}{p}\ \frac{100}{q}\ T^4$$

or
$$\theta = \sqrt[4]{\frac{10000\,\alpha}{\pi d^2}} \cdot \sqrt[4]{\frac{\beta}{pq\sin^2\rho}} \cdot T$$

$$= \frac{0{\cdot}13806}{\sqrt{\sin\rho}} \cdot \sqrt[4]{\frac{\beta}{pq}} \cdot T.$$

The mean value of $\frac{0{\cdot}13806}{\sqrt{\sin\rho}}$ is [1·30413].

Therefore
$$\theta = 1{\cdot}30413 \cdot \sqrt[4]{\frac{\beta}{pq}} \cdot T \quad \ldots\ldots\ldots\ldots (4).$$

After a series of observations had been made, the furnace and tube were raised so that the radiation of the latter then passed into the aperture (A), on which the sunlight had previously fallen, while the beam of sunlight was now directed so as to be upon (B), and in this position a second series of observations was taken. The geometrical mean of the result of the two groups gives the Effective Temperature of the Sun, the effect of any difference in the sensitiveness of the thermo-junctions disappearing in the geometrical mean.

Observations were made in the manner described above on August 19th and September 30th, 1901, and reduced by means of equation (4), as exhibited in the following tables. In these the successive columns contain (1) the local mean time, (2) the value of $\beta$ as read on the micrometer head, (3) the absolute temperature of the tube in the furnace, (4) the sun's altitude, (5) the percentage of the sun's radiation transmitted through the earth's atmosphere, (6) the angle of incidence on the heliostat mirror, (7) the percentage reflected from the surface of the mirror, (8) the corresponding value of $\theta$ deduced from equation (4). Of these (5) and (6) and (7) were determined as in Wilson and Gray's memoir referred to above.

| | | | |
|---|---|---|---|
| 62 | 9 | 5556 | First Position (B). |
| 62 | 9 | 5589 | 〃 |
| 62 | 9 | 5598 | 〃 |
| 62 | 9 | 5503 | 〃 |
| 62 | 9 | 5459 | 〃 |
| 63 | 11 | 5161 | 〃 |
| 64 | 12 | 5223 | 〃 |
| 64 | 12 | 5262 | 〃 |
| 64 | 12 | 5278 | 〃 |
| 64 | 12 | 5286 | 〃 |
| | Mean ..... | 5394 | 〃 |
| 68 | 15 | 6192 | Reversed Position (A). |
| 68 | 15 | 6184 | 〃 |
| 68 | 15 | 6186 | 〃 |
| 68 | 15 | 6190 | 〃 |
| 68 | 15 | 6210 | 〃 |
| 68 | 15 | 6193 | 〃 |
| 68 | 15 | 6190 | 〃 |
| 68 | 15 | 6190 | 〃 |
| 68 | 15 | 6186 | 〃 |
| 68 | 15 | 6202 | 〃 |
| | Mean ..... | 6192 | 〃 |

Note, $\alpha$ = 5 mm.

| Local time. | Balance. Reading. | Balance. Temp. absolute. | ⊙ Altitude. | Per cent. trans. | Angle of incidence. | Per cent. reflective. | ⊙ Temp. absolute. | Date, Sept. 30, 1901. Weather, slight haze. |
|---|---|---|---|---|---|---|---|---|
| h. m. | | ° | ° ′ | ° | | | ° | |
| 10 45 | 2·05 | 1107 | 31 30 | 59 | 64 | 11 | 5318 | First Position (B). |
| 10 52 | 2·16 | 1112 | 32 0 | 59 | 64 | 11 | 5379 | ,, |
| 10 55 | 2·17 | 1113 | 32 0 | 60 | 64 | 11 | 5364 | ,, |
| 11 25 | 2·55 | 1124 | 33 0 | 61 | 66 | 12 | 5146 | ,, |
| 11 38 | 2·42 | 1124 | 33 0 | 61 | 67 | 13 | 5320 | ,, |
| | | | | | | Mean..... | 5365 | |
| 11 51 | 5·20 | 1127 | 33 0 | 61 | 68 | 14 | 6302 | Reversed Position (A). |
| 11 55 | 6·05 | 1127 | 33 0 | 61 | 68 | 14 | 6585 | ,, |
| 12 0 | 6·02 | 1126 | 33 0 | 61 | 68 | 14 | 6570 | ,, |
| 12 8 | 5·39 | 1127 | 33 0 | 61 | 69 | 15 | 6290 | ,, |
| 12 18 | 5·67 | 1128 | 32 30 | 60 | 70 | 17 | 6201 | ,, |
| 12 25 | 5·18 | 1126 | 32 30 | 60 | 70 | 17 | 6053 | ,, |
| 12 32 | 5·25 | 1127 | 32 15 | 60 | 71 | 18 | 5992 | ,, |
| 12 36 | 5·18 | 1126 | 32 0 | 60 | 71 | 18 | 5968 | ,, |
| 12 50 | 5·55 | 1122 | 32 0 | 60 | 71 | 18 | 6050 | ,, |
| 12 58 | 5·25 | 1122 | 31 30 | 59 | 71 | 18 | 5992 | ,, |
| | | | | | | Mean..... | 6201 | |

Geometrical mean of A and B = $\sqrt{5365 \times 6201}$ = 5768°.

In the above tables Rosetti's determination of the amount of the terrestrial atmospheric absorption has been used. It may be well, however, to give the results obtained by using other estimates of this quantity. Taking Langley's transmission coefficient when the sun is in the zenith as 59 per cent., compared to Rosetti's 71 per cent., the temperature would be multiplied by $\sqrt[4]{(71/59)}$ and thus become $5773 \times 1{\cdot}054$, which is 6085° absolute. And, as in the previous memoir, to make the case general, if any later investigation shows the zenith transmission coefficient to be $x$ per cent., the effective absolute temperature becomes

$$5773^\circ \times \sqrt[4]{(71/x)}.$$

It may also be of interest to see what effect is produced if absorption in the atmosphere of the sun itself is taken into account. First, considering the falling off in radiation from the central to the peripheral parts of the sun's disc, we may deduce that, if the absorption were everywhere equal to that at the centre, the radiation would be multiplied by 4/3 and the temperature would become

$$5773^\circ \times \sqrt[4]{(4/3)} = 5773 \times 1{\cdot}074 = 6201^\circ.$$

Secondly, assuming Wilson and Rambaut's* result for the total loss due to absorption in the solar atmosphere as equal to one-third, our estimate of the temperature would have to be multiplied by $\sqrt[4]{(3/2)}$, and we get finally

$$6201^\circ \times \sqrt[4]{(3/2)} = 6201^\circ \times 1{\cdot}107 = 6863^\circ \text{ absolute} = 6590^\circ \text{ C.}$$

I wish to express my thanks to Dr. Rambaut for some valuable suggestions during the progress of the work.

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"The Chemical Origins of the Lines in Nova Persei." By Sir Norman Lockyer, K.C.B., F.R.S. Received December 23, 1901,—Read January 30, 1902.

In the first two papers† which I communicated to the Royal Society on the observations of Nova Persei at Kensington, a general description of the spectrum in its earliest stages was given, and also a statement as to the probable origins of some of the strongest lines, depending upon a comparison of the Nova Spectrum with those of $\alpha$ Cygni, $\alpha$ Canis Majoris, $\gamma$ Orionis, &c.

A table showing the results of the detailed reduction and discussion

* "The Absorption of Heat in the Solar Atmosphere," 'Proceedings Royal Irish Academy,' 1892, vol. 2, No. 2.

† 'Roy. Soc. Proc.,' vol. 68, p. 119 and p. 142.

Comparison Table of Bright Lines in the Spectra of Nova Persei and Nova Aurigæ with α Cygni Lines, Chromospheric Lines, and the Enhanced Lines of some of the Metals

| Nova Persei (Kensington). | | Nova Aurigæ. | | α Cygni. | Chromosphere (1898 Eclipse). | Enhanced lines. | | Remarks. |
|---|---|---|---|---|---|---|---|---|
| λ of middle of line. | Description of line. | Campbell. | Vogel. | | | λ. | Substance. | |
| 3836 | Very broad, weak ..... | — | 3835 | — | 3835·6 | — | — | H$\eta$. |
| 3889 | Very broad. ? Narrow reversal in centre | — | 3889 | 3889·1 | 3889·1 | — | — | H$\zeta$. |
| 3934 | Broad, rather weak. Fine narrow reversal in centre | — | 3934 | 3933·8 | 3933·83 | 3933·83 | *p*Ca | K(Ca). |
| 3969 | Very broad and fairly strong; shows fine narrow reversal in position of H(Ca) and possibly another weaker one in position of H$\epsilon$ | — | 3969 | 3968·6<br>3970·2 | 3968·63<br>3970·25 | 3968·63 | *p*Ca | H(Ca) + H$\epsilon$. |
| 3982<br>4003<br>4019 | All these are very weak diffuse lines which can just be seen with the unaided eye, but which will not bear any magnification, and their wavelengths can only be roughly determined | — | — | 4002·7 | — | 4002·77 | *p*Fe | |
| 4029 | | — | — | 4028·5 | 4028·5 | 4028·50 | *p*Ti | |
| 4067 | | — | 4067 | 4067·3 | 4067·3 | 4067·30 | *p*Ni | Strongest enhanced line of Ni. |
| | | 4082 | — | 4077·9 | 4077·9 | 4077·88 | *p*Sr | |
| 4102 | Broad and strong ..... | 4095<br>4102<br>4108 | 4102 | 4101·8 | 4101·9 | — | — | H$\delta$. |

Comparison Table—*continued.*

| Nova Persei (Kensington). | | Nova Aurigæ. | | α Cygni. | Chromosphere (1898 Eclipse). | Enhanced lines. | | Remarks. |
|---|---|---|---|---|---|---|---|---|
| λ of middle of line. | Description of line. | Campbell. | Vogel. | | | λ. | Substance. | |
| 4128 | Very broad and merging into Hδ | 4126 | 4125 | 4128·1<br>4131·1 | —<br>— | 4128·1<br>4131·1 | *p*Si<br>*p*Si | |
| | | 4166 | 4158 | 4163·8 | 4163·8 | 4163·82 | *p*Ti | |
| 4175 | Broad and fairly strong..... | 4180<br>4209 | 4176 | 4173·5<br>4179·0 | 4173·5<br>4179·0 | 4173·52<br>4178·95 | *p*Fe<br>*p*Fe | Mean λ of enhanced double = 4176·23. |
| 4232 | Broad, but not very strong ..... | 4227<br>4236 | 4230 | 4233·3 | 4233·3 | 4233·25 | *p*Fe | |
| 4247 | Comparatively narrow, but merging into the broader 4232 line, slightly stronger than the latter | 4246 | — | 4247·2 | 4247·0 | 4247·00 | *p*Sc | Strongest spark line of Sc. |
| 4262 | Narrow, but fairly strong ..... | 4267 | 4262<br>4288 | 4262·2<br>4290·4 | —<br>4290·2 | 4262·15<br>4290·38 | *p*Cr<br>*p*Ti | |
| 4300 | Broad line, fairly strong..... | 4296 | — | 4296·7<br>4300·2<br>4303·3 | 4296·7<br>4300·2<br>4303·0 | 4296·65<br>4300·21<br>4303·34 | *p*Fe<br>*p*Ti<br>*p*Fe | Mean λ of enhanced Fe double = 4300. |
| 4314 | Comparatively narrow, merging into 4300 | 4316 | 4315 | 4315·1 | 4314·0<br>4315·1 | 4315·14 | *p*Ti | Possibly due to Sc 4314·25, one of the strongest spark lines. |
| 4341 | Broad and very strong. Doubtful reversal in centre | 4331·3<br>4340·6<br>4347·8 | 4341 | 4340·7 | 4340·7 | — | — | Hγ. |
| | | 4355 | — | — | 4355 | | | |
| | | 4375<br>4385 | — | 4374·9 | 4374·9 | 4374·90 | *p*Ti | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4392 | Fairly broad, rather weak. | | | | | | | |
| 4411 | Broad and moderately strong . . . | — | — | 4411·2 | 4411·2 | 4411·20 | *p*Ti | |
| | | 4419 | 4417 | 4417·0<br>4417·9 | 4417·9 | 4417·88 | *p*Ti | |
| 4425 | Weak and rather narrow. | | | | | | | |
| 4434 | — — | 4436 | 4435 | 4434·4 | 4435·5 | | | |
| 4444 | Fairly broad, but weak . . . . . | 4445 | 4445 | 4444·0 | 4444·0 | 4443·98 | *p*Ti | |
| 4454 | Rather narrow, weak. | | | | | | | |
| 4470 | „ „ and weak . . . . . | 4471 | 4473 | 4468·7 | 4468·7 | 4468·66 | *p*Ti | |
| 4481 | „ „ fairly strong. . . . . | 4481 | 4480 | 4481 3 | | 4481·30 | *p*Mg | Strongest enhanced line of Mg. |
| 4493 | „ „ „ „ . . . . . | 4490 | 4495 | 4489·0<br>4491·6 | 4489·3<br>4491·6 | 4489·35<br>4491·57 | *p*Fe<br>*p*Fe | |
| 4509 | „ „ „ „ . . . . . | 4502 | 4507 | 4501·5 | 4501·5 | 4501·45 | *p*Ti | |
| | | | | 4508·5 | 4508·5 | 4508·46 | *p*Fe | |
| | | | | 4515·5 | 4515·5 | 4515·51 | *p*Fe | |
| 4519 | „ „ „ „ . . . . . | to | 4520 | 4520·4 | 4520·4 | 4520·40 | *p*Fe | |
| | | | | 4522·7 | 4522·7 | 4522·69 | *p*Fe | |
| 4535 | „ „ weak . . . . . | 4534 | 4530 | 4534·1 | 4534·1 | 4534·14 | *p*Ti | |
| 4548 | „ „ moderately strong | 4549 | — | 4549·8 | 4549·7 | 4549·64<br>4549·81 | *p*Fe<br>*p*Ti | |
| | | 4554 | 4557 | 4556·1 | 4556·1 | 4556·10 | *p*Fe | |
| | | 4559 | | 4558·8 | 4558·8 | 4558·83 | *p*Cr | |
| | | 4564 | — | 4563·9 | 4563·9 | 4563·94 | *p*Ti | |
| 4568 | „ „ „ „ | 4570 | — | 4572·2 | 4572·2 | 4572·16 | *p*Ti | |
| | | 4576 | — | 4576·5 | 4576·5 | 4576·51 | *p*Fe | |
| 4583 | „ „ but fairly strong. | 4586 | 4583 | 4584·0 | 4584·0 | 4584·02 | *p*Fe | |
| 4628 | Broad and fairly strong . . . . . | 4630 | 4628 | 4629·6 | 4629·5 | 4629·50 | *p*Fe | |
| 4670 | „ rather weak . . . . . | 4669 | | | | | | |
| 4705 | „ weak . . . . . | 4707 | — | — | 4707·8 | | | |
| | | 4737 | — | — | 4737·0 | | | |
| | | 4774 | | | | | | |
| *4822 | Fairly broad, weak . . . . . | — | — | 4824·3 | 4824·3 | 4824·33 | *p*Cr | Strongest enhanced line of Cr. |
| 4862 | Very broad and strong . . . . . | 4851·2<br>4861·6<br>4869·9 | 4862 | 4861·5 | — | — | — | H*β*. |

Comparison Table—*continued.*

| Nova Persei (Kensington). | | Nova Aurigæ. | | α Cygni. | Chromosphere (1898 Eclipse). | Enhanced lines. | | Remarks. |
|---|---|---|---|---|---|---|---|---|
| λ of middle of line. | Description of line. | Campbell. | Vogel. | | | λ. | Substance. | |
| 4924 | Broad and strong..... | 4913<br>4923<br>4929<br>4969 | 4923<br>4925 | 4924·1 | 4924·1 | 4924·11 | *p*Fe | |
| 5019 | „ „ ..... | 5007<br>5018<br>5095<br>5142 | 5016 | 5018·6 | 5018·6 | 5018·63 | *p*Fe | |
| 5169 | Broad and very strong ..... | 5159<br>5169<br>5176<br>5200 | 5167 | 5169·1 | 5169·1 | 5169·07<br>5169·22 | *p*Fe | Certainly not the *b*-group of magnesium. |
| *5224 | Narrow and weak. | 5234 | 523 | — | 5234·8 | | | |
| *5273 | „ „ ..... | 5276<br>5285 | 528 | — | 5275·1 to 5276·2 | 5276·17 | *p*Fe | |
| 5316 | Moderately broad and strong.... | 5318<br>5329<br>5379 | 5317 | 5316·8 | 5316·8 | 5316·79 | *p*Fe | |
| *5420 | Weak and rather narrow. | 5454 | | | | | | |
| *5475 | Weak and narrow. | | | | | | | |
| *5530 | Fairly strong and broad..... | 5535 | — | — | 5527·6 | 5527·03 | *p*Sc | By far the strongest spark line of Sc in the visual region |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *5575 | " | " | ..... | 5575<br>5584<br>5630 | } | | | | |
| *5686 | " | " | ..... | 5685<br>5761<br>5841 | | | | | |
| *5893 | " | " | ..... | 5885<br>5896 | 5686† | — | {5890·2<br>5896·2} | — | — | D(Na). |

† As given by Vogel (probably 5886).

*Note.*—The lines marked * cannot be seen in the photographs taken with the 6-inch prismatic camera, and their positions have been reduced from the spectrum photographed with the 30-inch reflector with a two-prism slit spectroscope.

of the bright lines in the best spectrum typical of the Nova in this early stage (that obtained with the 6-inch objective prism on February 25, when the star was nearly as bright as Capella), was undertaken later for inclusion in a general summary of the observations in course of preparation.

As various conclusions as to the chemical origin of some of the Nova lines have recently been published which differ widely from those arrived at from a careful study of the Kensington photographs, I think it desirable to publish the above-mentioned table at once. A detailed statement of the evidence on which these conclusions as to origin are based, will follow in the general summary before referred to.

That many of the stronger lines in the early spectra of Nova Aurigæ were chromospheric, has been pointed out by several observers, and all agree that there is little difference in the general aspect of the spectrum of Nova Aurigæ and that of Nova Persei at a corresponding stage of development. In confirmation of this it may be said that by means of direct comparison of the various Kensington photographs, the identity of most of the strong bright Nova bands with lines of $\alpha$ Cygni and the chromosphere—already known to be due to enhanced lines of certain metals—has been established.

With regard to the stellar relations of the Nova, I may state that in my note of February 28,* the agreement in position of its lines with those of $\alpha$ Cygni was pointed out. Later, Mr. McClean† confirmed this, and further stated that the bright lines of $\eta$ Argus corresponded with the dark lines of the Nova; while later still, Sir David Gill‡ has shown the similarity between the spectra of $\eta$ Argus and Nova Aurigæ. Hence we are led to the conclusion that the temperatures reached in the outbursts of both these Novæ were not greatly different from those of the stars named, and that in $\eta$ Argus there are constant conditions which are similar to those temporary conditions which produce the appearance of Novæ.

In the table the lines of Nova Persei are compared with those recorded by Campbell§ and Vogel‖ in Nova Aurigæ.

The probably corresponding lines of $\alpha$ Cygni, chromospheric lines, and enhanced lines, are also given in separate columns.

The reduction to wave-lengths and discussion of the lines in relation to those of other celestial and terrestrial spectra, has been undertaken by Mr. F. E. Baxandall, to whom my best thanks are due.

* 'Roy. Soc. Proc.,' vol. 68, p. 121.
† 'M.N., R.A.S.,' vol. 61, p. 387.
‡ 'Roy. Soc. Proc.,' vol. 68, p. 457.
§ 'Ast. and Ast. Phys.,' vol. 11, p. 808.
‖ 'Ast. and Ast. Phys.,' vol. 12, p. 912.

"On some Phenomena which suggest a Short Period of Solar and Meteorological Changes." By Sir NORMAN LOCKYER, K.C.B., F.R.S., and WILLIAM J. S. LOCKYER, M.A., Ph.D., F.R.A.S. Received June 14,—Read June 19, 1902.

In continuation of the inquiries referred to in a former paper on Indian rainfall and solar activity,* attention has more recently been devoted to an examination of the variations of pressure over the Indian and other areas.

1. It is well known that in India during the summer months (April to September) and during the winter months (October to March) low and high pressures respectively prevail. In the case of the latter, the pressure is found to exhibit very remarkable and definite variations, and is in excess, every $3\frac{1}{2}$ years, on the average, while at these times of excess of high pressure the low pressure during the other 6 months of the year is deficient; so that every $3\frac{1}{2}$ years or so the high pressure becomes higher and the low pressure is not so low as usual.

2. Further, this short-period variation, which appears in the mean variation of pressure over the whole of India, is as well defined in the mean values for individual stations, such as Bombay (fig. 1, Curve F), Calcutta, Madras, Nagpur, &c.

3. The view that the variation of pressure in question over India and its neighbourhood is not due to local causes, but is produced by some external or extra-terrestrial action, is considerably strengthened by an examination of the pressure-curve of a very distant station, such as Cordoba. Dealing with the pressure of Cordoba during the high-pressure months, April to September, the curve (fig. 2, Curves F and E), representing the variation from the mean from year to year, is exactly the *inverse* of the curve representing the Bombay and other Indian pressures for the same months over the same period of time. The cause, therefore which raises the mean value for the low-pressure months over the Indian area would appear to lower the mean value of high-pressure months at Cordoba simultaneously. In fact, we have a see-saw.

* 'Roy. Soc. Proc.,' vol. 67, p. 409.

4. Further investigation shows that not only do the pressures of practically the whole Indian area exhibit variations from year to year, which present very similar features, but that this is the case with

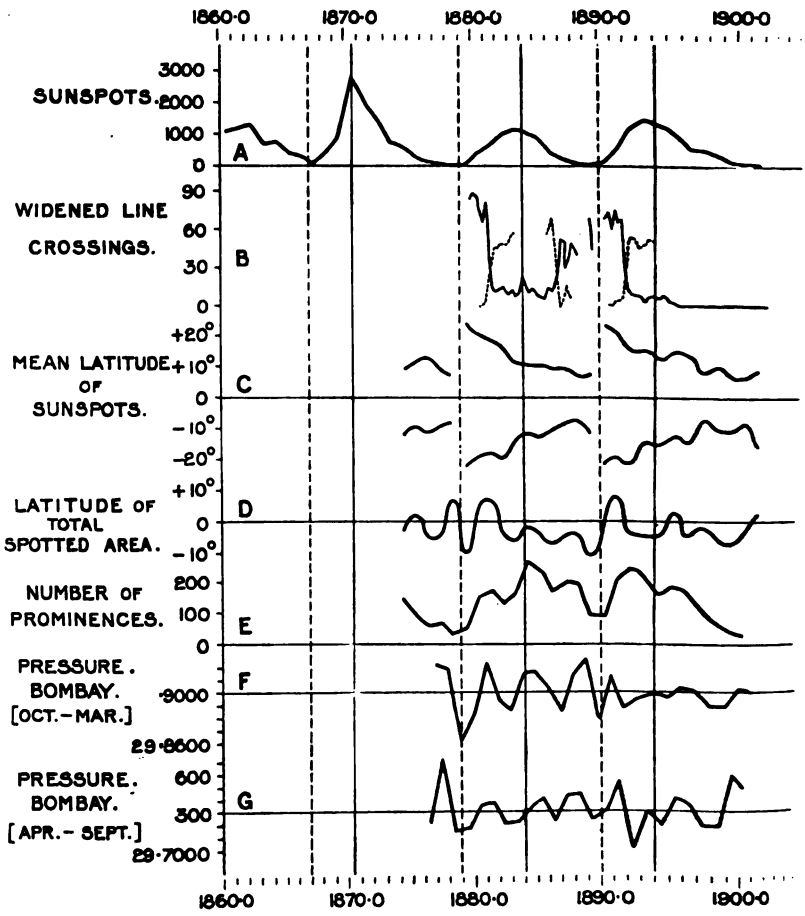



FIG. 1.

other large areas. Thus, for instance, it is found that the yearly mean pressures for Brussels, Bremen, Oxford, Valencia, and Aberdeen (the only pressures that have been at present examined) are all remarkably similar in their variations from year to year, and it might almost be said that one curve, representing the variations from the normal, would approximately define the pressures at all these places.

The probable extra-terrestrial origin of these short-period variations led to a detailed examination of the records of the phenomena con

nected with solar spots and prominences, with a view of seeing whether similar variations, indicating changes in the solar activity, could be detected.

5. A preliminary reduction of the Italian observations of prominences observed on the sun's limb since 1871 was first undertaken.

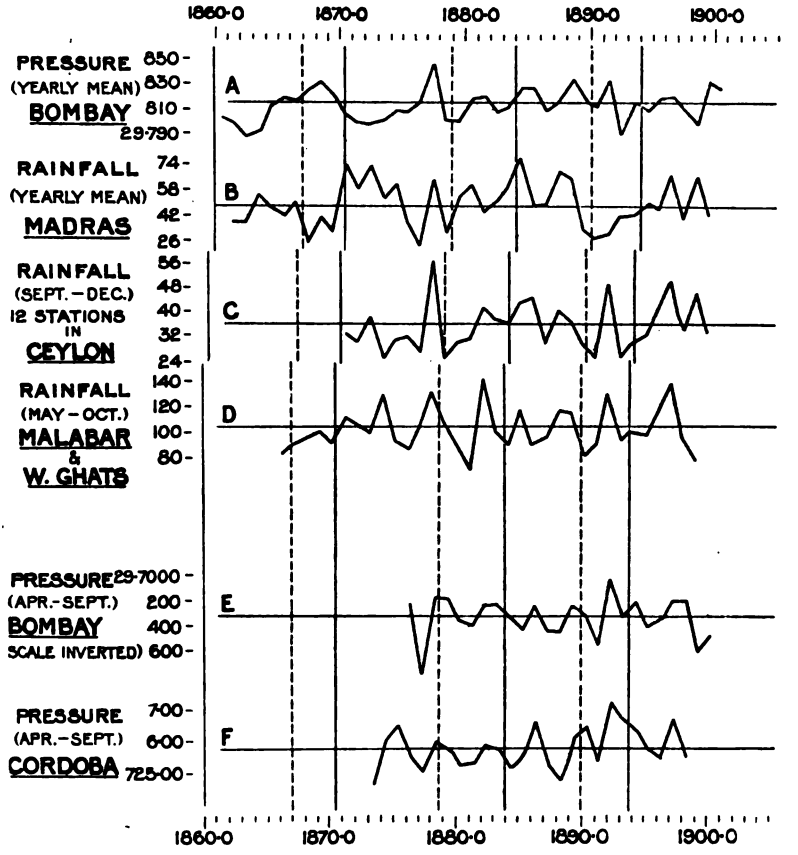



FIG. 2.

The result of this inquiry indicates that, in addition to the main epochs of maximum and minimum of prominences, which coincide in time with those of maximum and minimum of the total spotted area, there are prominent subsidiary maxima and minima having a similar short period and also coinciding in time. (Fig. 1, Curve E.)

6. Although these subsidiary prominence pulses are not distinctly duplicated in the curve representing the spotted area of the solar surface, it is to be noted that corresponding pulses are indicated in

the curves which represent the change of latitude of spotted area from year to year; and in each case an increase in prominence activity is associated with a decrease of latitude of the spotted area. (Fig. 1, Curves C and D.)

7. A comparison of these solar data with those already referred to relating to terrestrial pressures suggests that these simultaneous outbursts of prominences and changes of the latitudes in which the spots occur about every $3\frac{1}{2}$ years are the true cause of the pressure changes; and that the varying intensity of solar activity during the sunspot period of 11 years produces an effect on the pressure and circulation of our atmosphere, thus affecting the whole globe meteorologically.

8. The close correspondence between the epochs of these subsidiary pressure variations and those representing prominence frequency, suggests not only their very close relationship, but that the terrestrial pressure quickly answers to the solar changes, while so far as the work has gone it would appear that rainfall (fig. 2, Curves A, B, C, D) and snowfall are subsequent effects.

9. It may be remarked that we have already obtained evidence showing that this short-period variation is not the only one acting, but that the 11-year and 35-year periods apparently influence the short-period variations; but even this does not explain some anomalies already met with, and should the solar origin of these short-period pressure changes be subsequently confirmed, some of them not constant in all localities will have to be explained; and it is possible we may obtain in this way some new knowledge on the atmospheric circulation.

10. The period of time included in this survey begins generally with the establishment of the full records of the Indian Meteorological Department in 1875 and extends to 1895, when the regularity of the widened-line phenomena was broken, as stated in a previous communication.

ADDENDUM. Dated June 26.

In continuing the above researches we have plotted the percentage frequency of the solar prominences derived from the Italian observations for each 10° of solar latitude N. and S. of the Equator.

We find that the epochs of maximum prominence disturbance in the higher latitudes are widely different from those near the Equator. The latter are closely associated with the epochs of maximum spotted area; the former occur both N. and S. at intervening times.

We have then two sets of strongly marked prominence outbursts occurring at intervals of between 3 and 4 years.

Both sets are represented closely in the Indian pressure curves.

HARRISON AND SONS, Printers in Ordinary to His Majesty, St. Martin's Lane.

# LIST OF WORKS
## PRESENTED TO THE SOCIETY,
AND OF
## WORKS PURCHASED WITH THE TURNOR AND HORROX FUND,
## JUNE 1901 TO JUNE 1902.

*An asterisk (*) indicates that the work is an excerpt.*

**Acta Mathematica.** Zeitschrift, herausgegeben von G. Mittag-Leffler, Band 24, pt. 3—Band 25, pt. 2.
(*Turnor and Horrox Fund.*) 4to. Stockholm, 1901

**Adelaide, Government Observatory:**
Meteorological Observations made at the Adelaide Observatory and other places in South Australia and the Northern Territory during the year 1898, under the direction of Sir Charles Todd.
(*Observatory.*) fol. Adelaide, 1901

**Alberti (Vittorio):**
*Su la determinazione de' radianti.
(*Author.*) 8vo. Napoli, 1901

**Albrecht (F. und M.):**
Die Reste der Sternwarten Tycho Brahe's auf der Insel Hveen.
(*Turnor and Horrox Fund.*) 4to. Berlin, 1901

**Allegheny Observatory:**
Miscellaneous scientific papers; new series, No. 1–3. By F. L. O. Wadsworth, Director.
(*Observatory.*) 8vo. 1901

**American Academy of Arts and Sciences:** *see* Boston.

**American Journal of Mathematics.** Edited by T. Craig and S. Newcomb. Published under the auspices of the Johns Hopkins University. Vol. 23, No. 3—Vol. 24, No. 2.
(*Editors.*) 4to. Baltimore, 1901–1902

**American Journal of Science.** Editor E. S. Dana [and others]. Fourth series, Vol. 11, 12 (No. 67–78).
(*Editors.*) 8vo. New Haven, 1901–1902

**Amsterdam, Dutch Eclipse Expedition, 1901:**
1. Preliminary report of the Dutch Expedition to Karang Sago (Sumatra) for the observation of the total solar eclipse of May 1901.
2. Report of the Dutch observations, No. 2. Magnetic observations by W. van Bemmelen.
(*Dutch Eclipse Committee.*) 8vo. **Amsterdam**, 1902

**Amsterdam, Koninklijke Akademie van Wetenschappen:**
—— : Verhandelingen (Eerste Sectie), Deel 7, pt. 6–7.
(*Academy.*) 8vo. **Amsterdam**, 1900–1901
—— : Verslagen van de gewone Vergaderingen der Wis- en Natuurkundige Afdeeling, 1900-1901. Deel 9.
(*Academy.*) 8vo. **Amsterdam**, 1901
—— : Proceedings of the section of Sciences, vol. 3.
(*Academy.*) 8vo. **Amsterdam**, 1901
—— : Jaarboek, 1900.
(*Academy.*) 8vo. **Amsterdam**, 1901

**Arcètri, Reale Osservatorio:**
Pubblicazioni del R. Istituto di studi superiori pratici e di perfezionamento.
(*Observatory.*) 4to. **Firenze**, 1901
13. B. Viaro, Osservazioni astronomiche fatte al piccolo meridiano.
14. „ Sulla latitudine di Arcetri.
15. A. Abetti, Osservazioni astronomiche fatte, 1900.
L' Osservatorio astronomico di Arcetri.
A. Abetti. Galileo in Arcetri. Discorso Inaugurale.

**Astronomical Journal.** Founded by B. A. Gould [edited by S. C. Chandler]. Vol. 21, 22 (No. 499-521).
(*Editor.*) 4to. **Boston**, 1901–1902

**Astronomische Mittheilungen.** Gegründet von Rudolf Wolf: herausgegeben von A. Wolfer. No. 92.
(*Editor.*) 8vo. **Zürich**, 1901

**Astronomische Nachrichten:** Begründet von H. C. Schumacher: herausgegeben von H. Kreutz. Band 155–159 (No. 3721–3794).
(*Editor.*) 4to. **Kiel**, 1901–1902

—— : Astronomische Abhandlungen, als Ergänzungshefte zu den Astronomischen Nachrichten, herausgegeben von H. Kreutz. No. 2.
(*Editor.*) 4to. **Kiel**, 1901
J. Möller, Bestimmung der Bahn des Cometen, 1897, I.

**Astronomische Rundschau.** Herausgegeben von der Manora-Sternwarte in Lussinpiccolo (Oesterreich), unter der verantwortlichen Redaction von Leo Brenner. Band 3, 4 (Heft 25–36).
(*Turnor and Horrox Fund.*) 8vo. **Altenburg**, 1901–1902

**Astrophysical Journal (the).** An International Review of spectroscopy and astronomical physics. Edited by G. E. Hale [and others.] Vol. 13, No. 4—Vol. 15; No. 4.
(*Editors.*) 8vo. Chicago, 1901–1902

**Athenæum (the).** Journal of English and foreign literature, science, the fine arts, music, and the drama, 1901–1902. (No. 3842–3893.)
(*Editor.*) 4to. London, 1901–1902

**Athens, Observatoire National:**
Annales . . . publiées par Démétrius Eginitis. Tome 3.
(*Observatory.*) 4to. Athènes, 1901

**Australasian Association for the Advancement of Science:**
Report of the Eighth meeting . . . held at Melbourne, 1900.
(*Association.*) 8vo. Melbourne, 1901

**Auwers (Arthur):**
—— : *Rectascensionen von 792 Sternen nach Beobachtungen an den Meridianinstrumenten der Göttinger Sternwarten in den Jahren 1858 und 1859.
(*Author.*) 8vo. Göttingen, 1901
—— : *Mittlere Örter von 570 Sternen für das Aequinoctium 1815·0, aus den auf der Sternwarte Greenwich unter Direction von Pond in den Jahren 1811–1819 angestellten Beobachtungen abgeleitet.
(*Author.*) 4to. Berlin, 1902

**Bakhuyzen (E. F. van de Sande):**
*La déclinaison de la polaire d'après les observations faites à Königsberg de 1820 à 1849, et le mouvement propre de cette étoile.
(*Author.*) 8vo. Harlem . . .

**Barnard (Edward Emerson):**
—— : *Peculiarity of focal observations of planetary nebulæ, and visual observations of Nova Persei with the 40-in. Yerkes telescope.
(*Author.*) 8vo. Chicago, 1901
—— : *Recent observations of the position of Nova Aurigæ with the 40-in. telescope of the Yerkes Observatory.
(*Author.*) 8vo. London, 1901
—— : *The diameter of the Asteroid Juno (3) . . . with remarks on some of the other Asteroids.
(*Author.*) 8vo. London, 1901
—— : *Total eclipse of the Sun in Sumatra [1901 May 18].
(*Author.*) 8vo. Northfield, Minn., 1901
—— : *On the dimensions of the planets and satellites, and on the surface features of some of these bodies.
(*Author.*) 4to. Kiel, 1902

ırforschende **Gesellschaft:**
andlungen ; Band 13, Heft 2.
*ety.*) 8vo. Basel, 1901
andlungen : Namenverzeichniss und Sachregister
ände 6 bis 12, 1875–1900.
*ety*). 8vo. Basel, 1901

**versität:**
erzeichniss der schweizerischen Universitätsschriften,
–1901.
*versity.*) 8vo. Basel, 1901

**Koninklijke Natuurkundige Vereeniging in ıdsch-Indië:**
kundig Tijdschrift voor Nederlandsch-Indië. Deel
erie 10, Deel 4).
*ety.*) 8vo. Batavia, 1901

**oyal Magnetical and Meteorological Observa-**

rvations . . . published by order of the Government
etherlands India. Vol. 22, part 2.
*rvatory.*) 4to. Batavia, 1901
nwaarnemingen in Nederlandsch-Indië, Jaargang 22,

*rvatory.*) 8vo. Batavia, 1901

(H.):
tate für Mondort, Mondhalbmesser und Sonnen-
laxe abgeleitet aus den *Astr. Nachr.* 3457–58 veröf-
ichten Sternbedeckungen.

**Bergstrand (Östen)**—*continued.*

——: *Sur la parallaxe d'une étoile dans le voisinage de 61 Cygne.
(*Upsala Observatory.*) 8vo. Stockholm, 1901

**Berlin, Deutsche physikalische Gesellschaft:**

——: Die Fortschritte der Physik im Jahre 1900. Jahrgang 55, dritte Abtheilung, enthaltend kosmische Physik, redigirt von Richard Assmann.
(*Society.*) 8vo. Braunschweig, 1901

——: Die Fortschritte der Physik im Jahre 1902. Halbmonatliches Litteraturverzeichniss. Nos. 1–10 (Jan.–Jun.)
(*Society.*) 8vo. Braunschweig, 1902

——: Verhandlungen—Jahrgang 3, No. 8–10.
(*Society.*) 8vo. Berlin, 1901

**Berlin, Königlich Astronomisches Rechen-Institut:**

——: Berliner Astronomisches Jahrbuch für 1904; mit Angaben für die Oppositionen der Planeten (1)–(463) für 1902. Herausgegeben . . . unter Leitung von J. Bauschinger.
(*Institute.*) 8vo. Berlin, 1902

——: Veröffentlichungen. No. 15–17.
(*Institute.*) 4to. Berlin, 1901–1902

15. J. Bauschinger [&c.]. Genäherte Oppositions-Ephemeriden von 59 kleinen Planeten, 1901.
16. J. Bauschinger [&c.]. Tabellen zur Geschichte und Statistik der kleinen Planeten.
17. J. Bauschinger [&c.]. Genäherte Oppositions-Ephemeriden von 52 kleinen Planeten, 1902.

**Berlin, Königlich Preussische Akademie der Wissenschaften:**

——: Abhandlungen, 1901.
(*Academy.*) 4to. Berlin, 1901

——: Sitzungsberichte, 1901, No. 23—1902, No. 22.
(*Academy.*) 8vo. Berlin, 1901–1902

**Berlin, Königliche Sternwarte:**

Beobachtungs-Ergebnisse . . . Heft 9–11.
(*Observatory.*) 4to. Berlin, 1901–1902

9. V. Knorre. Zonenbeobachtungen.
10. H. Battermann. Resultate aus Beobachtungen von 560 Sternen.
11. H. Battermann. Bestimmung der Mondlänge, des Mondhalbmessers und der Sonnenparallaxe.

**Berlin, Vereinigung von Freunden der Astronomie und Kosmischen Physik:**

Mittheilungen, Jahrgang 11, Heft 6—Jahrgang 12 Heft 5.
(*Turnor and Horrox Fund.*) 8vo. Berlin, 1901–1902

**Bode (Johann Elert):**

Vorstellung der Gestirne auf xxxiv. Kupfertafeln, nach der Pariser Ausgabe des Flamstead'schen Himmelsatlas . . . nebst einer Anweisung zum Gebrauch und einem vollständigen Sternenverzeichnisse.
(*Turnor and Horrox Fund.*)
Obl. fol. Berlin und Stralsund, 1782

**Bombay Branch of the Royal Asiatic**
Journal, Vol. 21 (No. 57).
(*Society.*)

**Bonn, Königliche Sternwarte:**
Veröffentlichungen . . . herausgegeb
Küstner. No. 5.
(*Observatory.*)
C. Mönnichmeyer und Fr. Küstner. Beobs

**Bordeaux, Société des Sciences P**
relles:
Procès-verbaux des Séances, Année 1
(*Society.*) 8vo. P

**Boston, American Academy of Arts a**
—— : Memoirs: Vol. 12, pt. 2.
(*Academy.*) 4to. (
—— : Proceedings. Vol. 36, No. 24—Vo
(*Academy.*) 8vo. Bo

**Brahe (Tycho):**
—— : Tychonis Brahe Astronomiae instau
desburgi anno MDIIC, in memoriam re
practicae inclitissimi CCC abhinc a
ejus celeberrimum ad fidem editic
curavit et praefatus est B. Hasselb
(*Turnor and Horrox Fund.*)
—— : Tychonis Brahe Dani, die XXIV
defuncti, operum primitias de No
memor denuo edidit Regia Societas
(*R. Soc. of Sciences, Copenhagen.*)
—— : Bericht über die astrologischen St
der beobachtenden Astronomie, '
F. J. Studnička.
(*R. Bohemian Soc. of Sciences.*)
—— : Prager Tychoniana; zur beforsteh
Erinnerung an das vor 300 Jahre
Reformators der beobachtenden A
melt von F. J. Studnička.
(*R. Bohemian Soc. of Sciences.*)
—— : Bericht über die Untersuchung der
von H. Matiegka.
(*R. Bohemian Soc. of Sciences.*)
*See also* Albrecht (F.); Dunér (N.
Sällskapet.

**Brédikhine (Th.):**
—— : * Sur la Comète 1901 I.
(*Author.*) 4to
—— : * Sur le rôle de Jupiter dans la
composés.
(*Author.*) 8vo

**Brendel (Martin):**
* Nekrolog von Wilhelm Schur.
(*Author.*) 8vo. Leipzig, 1902

**Breslau, Königliche Universitäts-Sternwarte:**
Mittheilungen . . . Band 1. Herausgegeben von dem Direktor Julius H. G. Franz.
(*Observatory.*) 4to. Breslau, 1901

**Brisbane, Royal Geographical Society of Australasia:**
Queensland Geographical Journal (New Series), session 16, 1900–1901, Vol. 16.
(*Society.*) 8vo. Brisbane, 1901

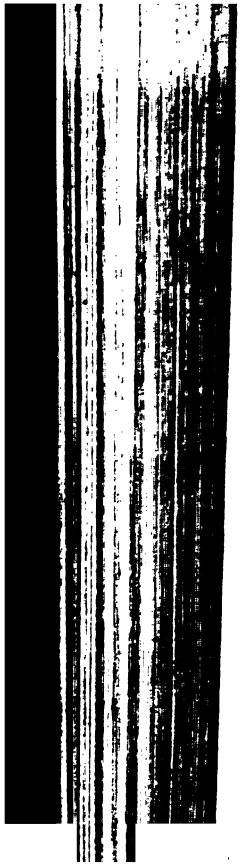
**British Association for the Advancement of Science:**
Report of the 71st meeting, 1901.
(*Association.*) 8vo. London, 1901

**Brown (Robert), Jun.:**
Researches into the origin of the primitive constellations of the Greeks, Phœnicians, and Babylonians. Vol. 2.
(*Turnor and Horrox Fund.*) 8vo. London, 1900

**Brussels, Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique:**
—— : Bulletin de la classe des sciences; 1899, 1900, 1901; 1902, No. 1–3.
(*Academy.*) 8vo. Bruxelles, 1899–1902
—— : Mémoires, tome 54, fasc. 1–4.
(*Academy.*) 4to. Bruxelles, 1900–1901
—— : Mémoires couronnés et mémoires des savants étrangers. Tome 57, 58; 59, fasc. 1 and 2.
(*Academy.*) 4to. Bruxelles, 1900–1901
—— : Mémoires couronnés et autres mémoires. (Collection in 8vo.) Tome 59–61.
(*Academy.*) 8vo. Bruxelles, 1899–1902
—— : Annuaire, année 66–68.
(*Academy.*) 8vo. Bruxelles, 1900–1902

**Budapest, Königl. Ungarische Reichsanstalt für Meteorologie und Erdmagnetismus:**
—— : Jahrbücher. Jahrgang 1900, Band 30, Theil 2.
(*Institute.*) 4to. Budapest, 1901
—— : Publicationen, 1901. Band 4.
(*Institute.*) 4to. Budapest, 1901

**Budapest, Magyar Tudományos Akadémia:**
—— : Almanach, 1901.
(*Academy.*) 8vo. Budapest, 1901
—— : Mathematikai és természettudományi Értesitö. Kotet 18, 3–5; Kotet 19, 1, 2.
(*Academy.*) 8vo. Budapest, 1900–1901
—— : Mathematikai és természettudományi Közlemények. Kotet 27, 5.
(*Academy.*) 8vo. Budapest, 1901



**Calcutta, Asiatic Society**
—— : Journal, Part 3, Vol.
(*Society.*)
—— : Proceedings, 1901, N
(*Society.*)

**Callandreau (O.):**
*Aperçu des méthodes p
comètes et planètes.
(*Author*).

**Cambridge Philosophical**
Proceedings, Vol. 11, pt.
(*Society.*)

**Canada, Geological Surve**
—— : Annual Report (New
(*Survey Office.*)
—— : General Index to the
(*Survey Office.*)

**Canada, Royal Society:**
Proceedings and Transac
(*Society.*)

**Cape of Good Hope, Roya**
—— : Results of meridian o
years 1877–79, under
reduced and printed
Gill.
(*Observatory.*)
—— : Results of meridian o
the years 1896–99, und
(*Observatory.*)
—— : Independent day numb

**Cape Town, South African Philosophical Society:**
Transactions, 1900. Vol. 11, pt. 3; vol. 12.
(*Society.*) 8vo. Cape Town, 1901

**Cardiff, Astronomical Society of Wales:**
The Cambrian Natural Observer. New series. Vol. 4, No. 3–5.
(*Society.*) 16mo. Cardiff, 1901–1902

**Cardiff, University College of South Wales & Monmouthshire:**
Calendar, 1901–2.
(*University.*) 8vo. Cardiff, 1902

**Catania, Reale Osservatorio:**
——: * Catalogo di stelle fondamentali fra +46° e +55°, equinozio del 1900·0. G. Boccardi.
(*Observatory.*) 4to. Catania, 1901
——: * Risultato delle osservazioni solari fatte . . . nel 1900. A. Mascari.
(*Observatory.*) 8vo. Catania, 1901
——: * Sulle protuberanze solari osservate . . . nell' anno 1900. A. Mascari.
(*Observatory.*) 4to. Catania, 1901
——: * Sulla frequenza e distribuzione in latitudine delle macchie solari osservate . . . nel 1899. A. Mascari.
(*Observatory.*) 4to. Catania, 1900
——: * Diformazione del sole all' orizzonte. A. Riccò.
(*Observatory.*) 4to. Catania, 1901
——: * Nova (3 1901) Persei: osservazioni astrofisiche. A. Riccò.
(*Observatory.*) 4to. Catania, 1901

**Catania, Società degli Spettroscopisti Italiani:**
Memorie . . . raccolte e pubblicate per cura del Prof. A. Riccò. Vol. 30, No. 5—Vol. 31, No. 4.
(*Society.*) 4to. Catania, 1901–1902

**Chandrasekhara (Mahamahopadhyaya Samanta):**
Siddhánta-Darpana: a treatise on astronomy. Edited, with an introduction, by Joges Chandra Ray.
(*Editor.*) 8vo. Calcutta, 1897

**Ciel et Terre.** Revue populaire d'astronomie, de météorologie et de physique du globe. Année 22, No. 8—Année 23, No. 7.
(*Turnor and Horrox Fund.*) 8vo. Bruxelles, 1901–1902

**Claridge (J. T. W.):**
The zodiacal light.
(*Author.*) 8vo. Tamworth, 1902

**Claxton (T. F.):**
* The total solar eclipse at Mauritius, 1901 May 18 [and 4 meteorological tracts].
(*Author.*) 8vo. Mauritius, 1901

**Cleomedes:**
Κλεομηδους κυκλικη θεωρια εις βιβλια β
excusa prodit, cum Regio Priuilegio
(*Turnor and Horrox Fund.*)

**Copenhagen, Kongelige Danske Viden**
—— : Oversigt over det K. Danske Videnskr
handlinger. 1901, No. 2–6; 1902,
(*Society.*) 8vo. Kj
—— : Skrifter, naturvidensk. og mathema
Bd. 9, No. 7, 8 : Bd. 10, No. 2, 3 :
(*Society.*) 4

**Cracow, Académie des Sciences:**
—— : Bulletin International: Comptes-r
1901, No. 4–10; 1902, No. 1–4.
(*Academy.*) 8vo
—— : Catalogue of the Polish scientific
Nos. 1–4.
(*Academy.*) 8vo.

**Deichmüller (F.):**
—— : Die astronomische Bewegungslehre
des Kardinals Nikolaus von Cusa.
(*Author.*)
—— : *Neue Methode zur Helligkeitsmess
Nebelflecken.
(*Author.*)
—— : *Die astronomischen Instrumente v
(*Author.*)

**Dijon, Académie des Sciences, Arts et**
Mémoires, 4me série, Tome 7, 1899–19
(*Academy.*)

**Dillmann (C. von):**
Astronomische Briefe, neue Folge
Fixsterne.
(*Turnor and Horrox Fund.*)

**Doyle (John):**
Magnetical dip and declination in the
(*Manila Observatory.*)

**Dublin, Royal Irish Academy:**
—— : Proceedings, third series, Vol. 6, N
(*Academy.*)
—— : Transactions, Vol. 31, part 8–11.
(*Academy.*)

**Dublin, Royal Society:**
—— : Scientific proceedings. New series
(*Society.*) 8
—— : Scientific transactions. Series II.
(*Society.*) 4

**Dunér (Nils Christian):**

—— : *Calcul des éléments elliptiques de l'orbite du système stellaire de l'étoile variable Y Cygni.
(*Author.*) 8vo. Stockholm, 1900

—— : *Om den på fotografisk väg framställda stjernkatalogen.
(*Author.*) 8vo. Stockholm, 1900

—— : *Calculation of elliptic elements of the system of Y Cygni.
(*Author.*) 8vo. Chicago, 1900

—— : *Observations and ephemerides of the variable star Y Cygni.
(*Author.*) 8vo. Chicago, 1901

—— : Tal vid K. Vetenskaps-Akademiens Minnesfest den 24 Oktober, 1901 ; trehundraårsdagen af Tycho Brahes död.
(*Author.*) 8vo. Stockholm, 1901

**Egypt, Survey Department:**

Meteorological Observations :—

—— : Abbassia, Cairo, March 1901 to March 1902.

—— : Alexandria, February 1901 to March 1902.

—— : Assiut, April 1901 to March 1902.

—— : Assuan, February 1901 to February 1902.

—— : Giza, January and February 1902.

—— : Omdurman, March 1901 to January 1902.

—— : Port Saïd, April 1901 to February 1902.

—— : Suakin, January and February 1902.
(*Survey Department.*) fol. 1901–1902

—— : Report on the meteorological observations made at the Abbassia Observatory, Cairo, 1898–99, together with the mean values derived from the observations of the previous 30 years.
(*Survey Department.*) 4to. Cairo, 1900

**English Mechanic (the) and World of Science:**

Vol. 73–75 (No. 1891–1942).
(*Editor.*) fol. London, 1901–1902

**Europe, Centralbureau der Internationalen Erdmessung:**

Verhandlungen der . . . dreizehnten allgemeinen Conferenz . . . 1900.
(*The Bureau.*) 4to. Berlin, 1901

**Fényi (Julius):**

—— : *Rise of a large prominence on June 1, 1900.
(*Haynald Observatory.*) 8vo. Chicago, 1900

—— : *Gewitter-Registrator, construirt von Johann Schreiber.
(*Haynald Observatory.*) 8vo. Kalocsa, 1901

**Flagg (Ambrose T.):**

Primer of navigation.
(*Author.*) 16mo. London, 1894

**Flammarion (Camille):**
Annuaire astronomique et météorologique pour 1902.
(*Editor.*) 8vo. Paris, 190

**Fritsche (H.):**
Die tägliche Periode der erdmagnetischen Element
[lithographed MS.]
(*Author.*) 8vo. St. Petersburg, 190

**Galilei (Galileo):**
Opere . . . Edizio Nazionale, sotto gli auspicii di Su
Maestà il Re d' Italia. Vol. 11.
(*Italian Government.*) 4to. Firenze, 190

**Galway, Queen's College:**
Calendar for 1901–1902.
(*College.*) 8vo. Dublin, 190

**Gautier (Raoul):**
—— : Rapport de la commission chargée de l'étude des épreuve
et concours pour les chronomètres.
(*Author.*) 4to. Paris, [190
—— : *Observations météorologiques faites aux fortifications d
Saint-Maurice pendant l'année 1900. Résumé pa
R. G. . . .
(*Author.*) 8vo. Genève, 190
—— : Rapport sur le Concours de réglage de chronomètres 190
(*Author.*) 8vo. Genève, 190

**Geneva, Observatoire:**
*Résumé météorologique . . . pour Genève et le Gran
Saint-Bernard, par R. Gautier, 1900.
(*Observatory.*) 8vo. Genève, 190

**Geneva, Société de physique et d'histoire naturelle:**
Mémoires, tome 34, fasc. 1.
(*Society.*) 4to. Genève, 190

**Georgetown College Observatory:**
—— : Preliminary light curve of Nova Persei from February 2
to May 1.
(*Observatory.*) 4to. Georgetown, [1901
—— : Supplementary notes to the Atlas Stellarum Variabilium
I. The new star in Perseus. II. Some engraved charts o
Pogson's proposed atlas.
(*Observatory.*) 4to. Washington, 1901

**Göttingen, Königliche Gesellschaft der Wissenschaften:**
Nachrichten, mathematisch-physikalische Klasse.
1901, Heft 1, 2; 1902, Heft 1.
(*Society.*) 8vo. Göttingen, 1901–190

**Greenwich, Royal Observatory:**

—— : Astronomical and magnetical and meteorological observations made . . . 1899, under the direction of W. H. M. Christie.
(*Observatory.*) 4to. London, 1901

—— : Appendices:
Results of Astronomical Observations, 1899.
Results of Magnetical and Meteorological Observations, 1899.
Results of Spectroscopic and Photographic Observations, 1899.
P. H. Cowell. Tables to facilitate the reduction of transits.
Report of the Astronomer Royal to the Board of Visitors, 1902.
(*Observatory.*)

**Groningen, Astronomical Laboratory:**

Publications No. 5, 8. Edited by J. C. Kapteyn.
(*The Laboratory.*) 4to. Groningen, 1901
5. J. C. Kapteyn. On the distribution of cosmic velocities. Part 1. Theory.
8. J. C. Kapteyn. Mean parallax of stars of determined proper motion and magnitude.

**Hadden (David E.):**

—— : *The total solar eclipse of 1900 May 28, observed at Wadesboro, N.C.
(*Author.*) 8vo. Des Moines, 1901

—— : Review of Solar observations for the year 1900, at Alta, Ia. Auroral phenomena at Alta, Ia.
(*Author.*) 8vo. Northfield, Minn., 1902

**Halle, Kaiserliche Leopoldinisch-Carolinische Akademie der Naturforscher:**

—— : Abhandlungen (Nova Acta). Band 77–79.
(*Academy.*) 4to. Halle, 1901

—— : Leopoldina . . . . herausgegeben von K. von Fritsch. Heft 36. Jahrgang 1900.
(*Academy.*) 4to. Halle, 1900

—— : Geschichte der Bibliothek und Naturaliensammlung . . . . von O. Grulich.
(*Academy.*) 8vo. Halle, 1894

—— : Repertorium zu den Acta und Nova Acta der Akademie, von A. Graesel. Band 1, 2.
(*Academy.*) 4to. Halle, 1894–1899

**Hamburg, Sternwarte:**

—— : *Bericht . . . für 1900.
(*Observatory.*) 8vo. Hamburg, 1901

—— : Mittheilungen, No. 7.
(*Observatory.*) 8vo. Hamburg, 1901
R. Schorr und A. Scheller. Catalog von 344 Sternen zwischen +79°50′ und +81°10′.

**Hartwig (Ernst):**

*Ephemeriden veränderlicher Sterne für 1902.
(*Author.*) 8vo. Leipzig, 1902

**Harvard College Astronomical Obser**
——: Annals, Vol. 28, pt. 2; Vol. 41, N
(*Observatory.*) 4to. Cambri
Vol. 28, pt. 2. Annie J. Cannon. Spect
(Henry Draper Memor
„ 41, No. 7. A. Searle. Results obtai
apparatus in meridian
„ 48, „ 1. Stars near the North Pol
——: Circular, No. 59–65.
(*Observatory.*) 4to. Cambri
——: Fifty-sixth annual report of the Dir
By E. C. Pickering.
(*Observatory.*) 8vo. C

**Heath (Thomas):**
*Observations of the Edinburgh rock
(*Author.*)

**Heidelberg, Grossherzogliche Sternw**
**risches Institut):**
Mittheilungen .... Herausgegeben v
(*Observatory.*)
E. Jost. Photometrische Beobachtung de

**Heimbrod (G.):**
*Tables for determination of latitude
tude observations of σ Octantis out
(*Author.*)

**Helmert (Friedrich Robert):**
——: *Zur Bestimmung kleiner Flächens
Lothabweichungen mit Rücksicht
Zweite Mittheilung.
(*Author.*)
——: *Dr. Hecker's Bestimmung der S
Atlantischen Ocean.
(*Author.*)
——: *Über die Reduction von Lotabweic
gelegenes Niveau.
(*Author.*)

**Helsingfors, Finska Vetenskaps Soci**
——: Acta Societatis Scientiarum Fennic
(*Society.*) 4t
——: Öfversigt af Finska Vetenskaps-Soci
43, 1900–1901.
(*Society.*) 8

**Hill (George William):**
——: List of papers chronologically arran
(*Author.*)
——: *Secular perturbations of the planet
(*Author.*)

**Himmel und Erde.** Illustrierte naturwissenschaftliche Monatsschrift, herausgegeben von der Gesellschaft Urania; Redacteur P. Schwahn. Jahrgang 13, Heft 10—Jahrgang 14, Heft 8.
(*Editor.*) 8vo. Berlin, 1901–1902

**Hong Kong Observatory:**
Observations and researches made . . . in the year 1900, by W. Doberck.
(*Observatory.*) fol. Hong Kong, 1901

**Horological Journal (the):**
Vol. 43, 44 (No. 515–526).
(*Brit. Horol. Institute.*) 8vo. London, 1901–1902

**Hovestadt (H.):**
Jenaer Glas und seine Verwendung in Wissenschaft und Technik.
(*Turnor and Horrox Fund.*) 8vo. Jena, 1900

**Hutton (Frederick Wollaston):**
The lesson of evolution.
(*Author.*) 8vo. London, 1902

**Huygens (Christiaan):**
Œuvres complètes . . . . publiées par la Société Hollandaise des Sciences. Tome 9. Correspondance, 1685–1690.
(*Turnor and Horrox Fund.*) 4to. La Haye, 1901

**India, Survey Department:**
—— : General report on the operations of the Survey of India Department . . . during 1899–1900.
(*H.M. Govt. in India.*) fol. Calcutta, 1901

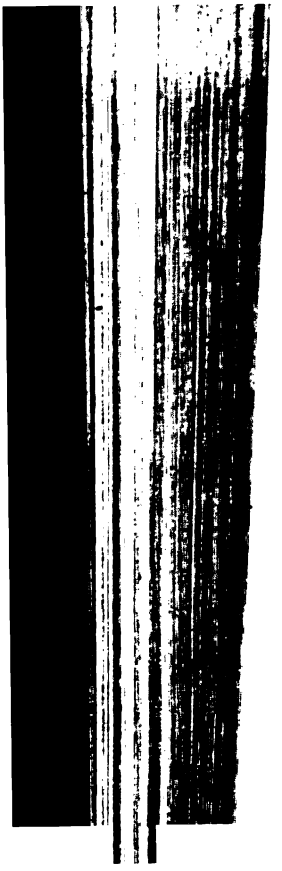
—— : Professional Papers, No. 5.
(*H.M. Govt. in India.*) 4to. Dehra Dûn, 1901
Major S. G. Burrard, The attraction of the Himalaya Mountains upon the plumb-line in India.

**Indian Engineering:**
An illustrated weekly journal, edited by Pat. Doyle. Vol. 29, No. 21—Vol. 31, No. 20.
(*Editor.*) fol. Calcutta, 1901–1902

**Jacoby (Harold):**
Comparison of methods for the reduction of star-photographs.
(*Author.*) 4to. Boston, 1901

**Johnson (Richard Coward):**
*Notes on observations of total solar eclipses, 1851–1900.
(*Author.*) 8vo. Liverpool, 1900

**Kalocsa, Haynald-Observatorium:**
Publicationen . . . . Heft 8.
(*Observatory.*) 4to. Kalocsa, 1902
J. Fényi. Protuberanzen beobachtet in den Jahren 1888–90.



and art. Vol. 24, 25 (
(*Turnor and Horrox*

**Langley (Samuel Pierpo**
*The new spectrum.
(*Author.*)

**Law (Edward Downes):**
*Diagrams on work-boo
and a short and eas
error of a sextant.
(*Author.*)

**Lebon (Ernest):**
Notice sur les travaux n
(*Author.*)

**Leeds Philosophical and l**
81st Annual Report, 19c
(*Society.*)

**Leipzig, Astronomische G**
—— : Catalog der Astronomi
lung; Catalog der
zwischen 80° nördlich
das Æquinoctium 187
(*Society.*)
Zone + 35° bis + 40°. (Lu
—— : Vierteljahrsschrift, Jah
(*Society.*)

**Leipzig, Königlich Sächsi**
schaften:
—— : Abhandlungen, mathem
No. 5, 6. Band 27, Nc
(*Society.*)

**Lick Observatory, University of California:**
—— : Bulletin, No. 2–18.
(*Observatory.*) 4to. 1901–1902.
—— : Publications. Vol. 5 : Vol. 7, pt. 1–3.
(*Observatory.*) 4to. Sacramento, 1901–1902
Vol. 5. W. J. Hussey. Micrometrical measures of double stars.
Vol. 7. pt. 1. A. O. Leuschner. A short method of determining orbits from three observations.
„ „ 2. A. O. Leuschner and A. M. Hobe. Elements of Asteroid 1900 G.A.
„ „ 3. R. H. Curtiss and C. G. Dall. Preliminary elements of Comet 1900 III.

**Liverpool Literary and Philosophical Society:**
Proceedings . . . No. 55 (1900–1901).
(*Society.*) 8vo. Liverpool, 1901

**Liverpool Observatory:**
Report of the director of the observatory to the Marine Committee, and meteorological results . . . 1900.
(*Observatory.*) 8vo. Liverpool, 1901

**Lockyer (Sir J. Norman):**
—— : *Total eclipse of the Sun, 1900 May 28. Account of the observations made by the Solar Physics Observatory eclipse expedition, and the officers and men of H.M.S. "Theseus" at Santa Pola, Spain.
(*Solar Physics Committee.*) 4to. London, 1902
—— : *On the spark discharge from metallic poles in water.
(*Solar Physics Committee.*) 8vo. London, 1902

**Lockyer (Sir J. Norman) and F. E. Baxandall:**
—— : *On the enhanced lines in the spectrum of the chromosphere.
(*Authors.*) 8vo. London, 1901
—— : *On the arc spectrum of Vanadium.
(*Author.*) 8vo. London, 1901

**Lockyer (Sir J. Norman) and W. J. S. Lockyer:**
*On solar changes of temperature and variations in rainfall in the regions surrounding the Indian Ocean.
(*Authors.*) 8vo. London, 1900

**Lockyer (Sir J. Norman), Capt. Chisholm-Batten, and A. Pedler:**
*Total eclipse of the Sun, 1898 January 22 : observations at Viziadrug.
(*Solar Physics Committee.*) 4to. London, 1901

**Lockyer (William J. S.):**
*The solar activity, 1833–1900.
(*Author.*) 8vo. London, 1901

**Loewy (Maurice):**
*Étude des conditions à réaliser dans pour obtenir l'homogénéité et le max la détermination des coordonnées d (*Author.*)

**London, British Astronomical Associ**
——: Journal, Vol. 11, No. 8—Vol. 12, (*Association.*) 8
——: Memoirs, Vol. 9, pt. 4; Vol. 10, (*Association.*) 8
——: List of members, 1901.

**London, Camera Club:**
Journal, Vol. 15–16 (No. 182–192). (*The Club.*) 4

**London, Geological Society:**
——: Quarterly Journal, Vol. 57, pt. (No. 227–230). (*Society.*) 8
——: Geological literature added to the . (*Society.*)
——: List of Fellows, 1901. (*Society.*)

**London, Meteorological Office:**
——: Hourly means of the readings ot recording instruments at the five O Meteorological Council, 1898. (*The Office.*)
——: Meteorological Observations at s order for the year 1898. (*The Office.*)
——: Temperature tables for the British for the thirty years 1871 to 1900. (*The Office.*)
——: Weekly weather report, Vol. 18, N (*The Office.*) 4

**London, Nautical Almanac and Astr**
for the meridian of the Royal Observat (*Lords Commissioners of Admiralty*
——: Ditto, Part 1; containing such po for navigation, 1905. (*Lords Commissioners of Admiralty*
——: Appendix to the Nautical Almana the apparent places of Nautical Al Greenwich. (*Lords Commissioners of Admiralty*

**London, Physical Society:**
Proceedings, Vol. 17, pt. 6—Vol. 18, (*Society.*) 8

**London, Royal Geographical Society:**
The Geographical Journal, including the Proceedings of the Royal Geographical Society. Vol. 18, 19.
(*Society.*) 8vo. London, 1901–1902

**London, Royal Institution:**
Proceedings, 1900. Vol. 16, pt. 2 (No. 94).
(*Institution.*) 8vo. London, 1901

**London, Royal Meteorological Society:**
—— : Quarterly Journal, Vol. 27, 28 (No. 119–122).
(*Society.*) 8vo. London, 1901–1902
—— : The Meteorological Record: Monthly results of observations made at the stations of the Royal Meteorological Society, with remarks on the weather . . . by W. Marriott. Vol. 20, 21 (No. 79–83).
(*Society.*) 8vo. London, 1901–1902
—— : An account of the bequest of G. J. Symons. By W. Marriott.
(*Society.*) 8vo. London, 1901

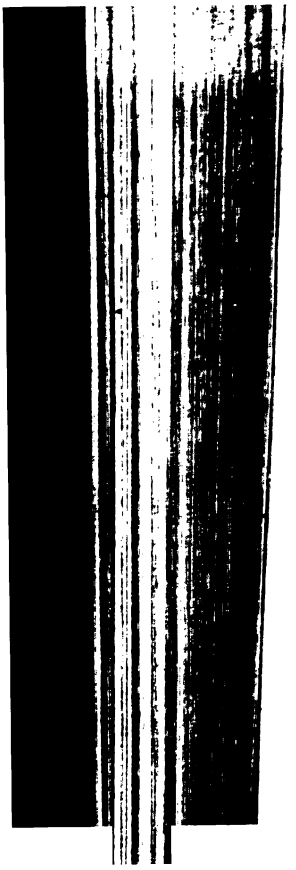
**London, Royal Photographic Society:**
The Photographic Journal; including the Transactions of the Royal Photographic Society, Vol. 25, No. 10—Vol. 26, No. 4.
(*Society.*) 8vo. London, 1901–1902

**London, Royal Society:**
—— : Philosophical transactions, Series A, Vol. 194–196.
(*Society.*) 4to. London, 1900–1901
—— : Proceedings, Vol. 68–70 (No. 446–460).
(*Society.*) 8vo. London, 1901–1902
—— : List of Fellows, 1900.
(*Society.*) 4to. London
—— : Report of the Meteorological Council for the year ending 31st March, 1901.
(*Meteorological Office.*) 8vo. London, 1901
—— : Catalogue of Scientific Papers (1800–1883). Supplementary volume. Vol. 12.
(*Society.*) 4to. London and Cambridge, 1902
—— : Year-book of the Royal Society of London, 1902.
(*Society.*) 8vo. London, 1902

**London, Royal United Service Institution:**
Journal, Vol. 45, 46 (No. 280–290).
(*Institution.*) 8vo. London, 1901–1902

**London, Society of Arts:**
Journal, Vol. 49, 50 (No. 2534–2585).
(*Society.*) 8vo. London, 1901–1902

**London, Solar Physics Observatory:**
Catalogue of four hundred and seventy of the brighter stars classified according to their chemistry.
(*Observatory.*) 4to. London, 1902



Lund, Kongl. Fysiograf
Festskrift . . . i anle
död. Utgräfningarn
Hven sommaren 19
(*Lund Observatory.*)

**Lynn (William Thynn**
——: Remarkable Comet
facts in the histo
edition.
(*Author.*)
——: Remarkable Eclips
circumstances conn
lunar eclipses both
edition.
(*Author.*)

**Madison, Washburn Ob**
Publications, Vol. 1
(*Observatory.*)

**Madras and Kodaikána**
Report . . . for the y
(*Observatory.*)

**Madrid Observatorio As**
——: Memoria Anual del
(*Observatory*).
——: Observaciones metec
*Observatory.*)

**Madrid, Real Academia**
**naturales:**
Memorias, Tomo 14 [a
(*Academy.*)

**Manchester Literary and Philosophical Society:**
Memoirs and Proceedings, Vol. 45, pt. 3—Vol. 46, pt. 5.
(*Society.*) 8vo. Manchester, 1901–1902

**Manila, Observatorio:**
Boletín Mensual. Año 1899, 1900; 1901, trimestre 1, 2.
(*Observatory.*) 4to. Manila, 1901–1902

**Manila, Philippine Weather Bureau:**
Monthly Bulletins. 1901 Nov. and Dec.
(*Bureau.*) 4to. Manila, 1902

**Marriott (William):**
Hints to Meteorological Observers; instructions for taking observations and tables for their reduction. . . . Fifth edition.
(*R. Meteorol. Soc.*) 8vo. London, 1902
*See also* London, Royal Meteorological Society.

**Maunder (E. W.):**
*Preliminary account of the total solar eclipse of 1901 May 18, as observed at the Royal Alfred Observatory.
(*Author.*) 8vo. Mauritius, 1901

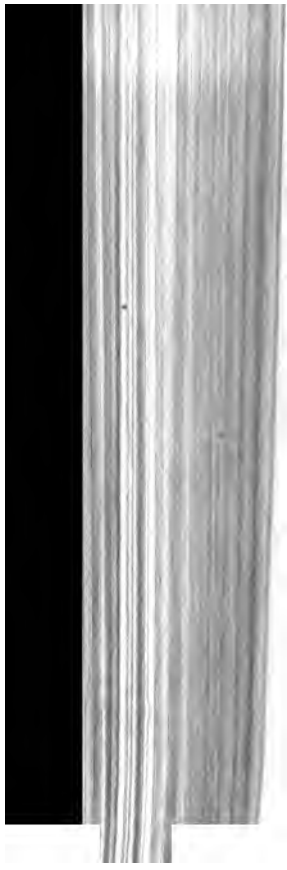
**Mauritius Meteorological Society:**
Proceedings and Transactions. New series. Vol. 1.
(*Society.*) 8vo. Mauritius, 1900

**Mauritius, Royal Alfred Observatory:**
—— : Annual Report of the Director for the years 1899, 1900.
(*Observatory.*) fol. Mauritius, 1900–1901
—— : Results of magnetical and meteorological observations made . . . in the year 1899 under the direction of T. F. Claxton.
(*Observatory.*) fol. Mauritius, 1900

**Mee (Arthur B. P.):**
Observation without instruments.
(*Author.*) 16mo. Cardiff, 1901

**Melbourne Observatory:**
—— : Record of results of observations in meteorology and terrestrial magnetism, . . . 1900 July–Dec.; 1901 Jan.–June, under the direction of P. Baracchi.
(*Observatory.*) 8vo. Melbourne, 1901
—— : Thirty-fifth Report of the Board of Visitors, . . . together with the report of the Government Astronomer, 1900–1901.
(*Observatory.*) fol. Melbourne, 1901

**Meyer (Edward):**
The Structure and inherent motions of the Universe.
(*Author.*) 8vo. Adelaide, 1901



**Moncalieri, Osservatorio Alberto:**
Bollettino mensuale
Serie 2, Vol. 20, No.
(*Observatory.*)

**Montpellier, Académie d**
Mémoires de la section
No. 1.
(*Academy.*)

**Moscow, Société Impéria**
Bulletin, Année 1901, N
(*Society.*)

**Munich, Königlich bay schaften:**
—— : Abhandlungen der n
Band 21, Abth. 2.
(*Academy.*)
—— : Sitzungsberichte der r
1900, Heft 2–4; 1902
(*Academy.*)

**Naples, Società Reale (R.**
Rendiconto dell' Accade
tiche: Serie 3. Vol.
40, 41.)
(*Academy.*)

**Natal Observatory:**
Report of the Governmen
(*Observatory.*)

**Nature.** A

**Naturwissenschaftliche Rundschau.** Wöchentlicher Bericht über die Fortschritte auf dem Gesammtgebiete der Naturwissenschaften . . . herausgegeben von W. Sklarek. Jahrgang 16, No. 25—Jahrgang 17, No. 24.
(*Editor.*) 4to. Braunschweig, 1901–1902

**Newcomb (Simon):**
—— : *A rude attempt to determine the total light of all the stars.
(*Author.*) 8vo. Chicago, 1901
—— : The Stars ; a study of the Universe.
(*John Murray.*) 8vo. London 1901

**New York, Observatory of Columbia University:**
Contributions, No. 19.
(*Observatory.*) 8vo. New York, 1902
H. Jacoby. Catalogue of 287 stars near the South Pole.

**Nipher (Francis E.):**
—— : *The relation of direct to reverse photographic pictures.
(*Author.*) 8vo. St. Louis, Mo., 1901
—— : *The specific heat of gaseous nebulæ in gravitational contraction.
(*Author.*) 8vo. St. Louis, Mo., 1901

**Norie (J. W.):**
A complete set of Nautical Tables. . . . New edition, by W. H. Rosser.
(*Turnor and Horrox Fund.*) 8vo. London, 1890

**Norwegian North-Atlantic Expedition, 1876–78:**
No. 28. Zoologi.
(*Norwegian Government.*) 4to. Christiania, 1901

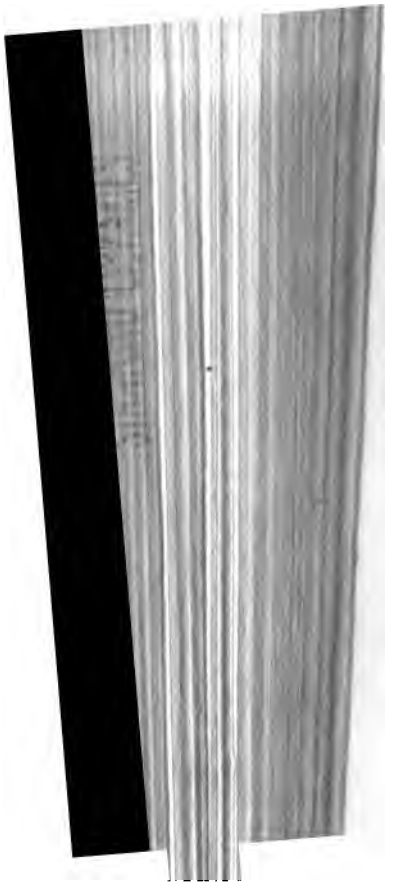
**Observatory (The).** A monthly review of astronomy ; edited by T. Lewis and H. P. Hollis, Vol. 24, 25 (No. 307–319).
(*Editors.*) 8vo. London, 1901–1902

**Odessa, Observatoire:**
Observations de protubérances solaires faites . . . 1893–1901.
(*Observatory.*) 8vo. Odessa, 1900–1901

**O-Gyalla, Königl. ung. meteorologisch-magnetisches Central-Observatorium:**
Beobachtungen angestellt Mai 1901–März 1902.
(*Observatory.*) 4to. Budapest, 1901–1902

**Oxford, Radcliffe Observatory:**
Results of meteorological observations made . . . in the eight years 1892–1899. Edited by A. A. Rambaut.
(*Observatory.*) 4to. Oxford, 1901

**Paris, Académie des Sciences:**
Comptes rendus hebdomadaires des séances. Tome 132, No. 23—Tome 134, No. 22.
(*Academy.*) 4to. Paris, 1901–1902



——: Éphéméri
longitude,
(*The Burea*

**Paris, Congrès A**
——: Carte Pho
+5°, +7°,
Toulouse, F
Observatoric
(*The Ministe*
——: Conférence A
Circulaire, N
(*Académie des*
——: Réunion du C
(*Académie des*

**Paris, Dépôt Génér**
Annales Hydrogr
(*Depôt of Mari*

**Paris, École Polyte**
Journal. Série 2,
(*École Polytech*

**Paris, Observatoire:**
——: Annales . . . p
Observations, 1
(*Observatory.*)
——: Atlas photogra
Lœwy et P. Puis
(*Observatory.*)
——: Rapport annuel
M. Lœwy.
(*Observatory.*)

**Paris, Société Française de Physique:**
Rapports présentés au Congrès International de Physique, réuni à Paris en 1900 . . . rassemblés et publiés par C. E. Guillaume et L. Poincaré. Tome 2; Optique, Electricité, Magnétisme.
(*Turnor and Horrox Fund.*) 8vo. Paris, 1900

**Paris, Société Mathématique de France:**
Bulletin. Tome 29, fasc. 3—Tome 30, fasc. 1.
(*Society.*) 8vo. Paris, 1901–1902

**Paris, Société Philomathique:**
Bulletin. 9me série. Tome 3, Nos. 1–4; Tome 4, No. 1.
(*Society.*) 8vo. Paris, 1901–1902

**Passalsky (P.):**
Anomalies magnétiques dans la région des mines de Krivoï-Rog.
(*B. Weinberg.*) fol. Odessa, 1901

**Pennsylvania, Sayre Observatory:**
* Results of observation with the zenith telescope . . . Jan. 19, 1894, to Aug. 19, 1895. By C. L. Doolittle.
(*Prof. Doolittle.*) 4to. Philadelphia, 1901

**Penrose (F. Cranmer):**
On the method of predicting by graphical construction Occultations of Stars by the Moon and Solar Eclipses for any given place; together with more rigorous methods of reduction for the accurate calculation of Longitude. (Second edition.)
(*Author.*) fol. London, 1902

**Philadelphia, American Philosophical Society:**
—— : Proceedings, Vol. 40, No. 165–167.
(*Society.*) 8vo. Philadelphia, 1901
—— : Transactions. New series. Vol. 20, pt. 2.
(*Society.*) 4to. Philadelphia, 1901

**Philadelphia, Franklin Institute:**
Journal, year 76, 77. Vol. 151, No. 6—Vol. 153, No. 5.
(*Institute.*) 8vo. Philadelphia, 1901–1902

**Philadelphia, University of Pennsylvania:**
Publications. Vol. 1, pt. 3.
(*Observatory.*) 4to. Philadelphia, 1901
E. Doolittle. Measures of 900 double and multiple stars.

**Philosophical Magazine:**
The London, Edinburgh, and Dublin Philosophical Magazine. Series 6, Vol. 2, 3. (No. 7–18.)
(*Turnor and Horrox Fund.*) 8vo. London, 1901–1902

**Pickering (William H.):**
* Is the Moon a dead planet?
(*Author.*) 4to. [New York], 1902

**Plummer (H. C.):**

* **A method of mechanically compensating the rotation o the field of a siderostat. Note on the geometry of th siderostat.**

(*University Observatory, Oxford.*) 8vo. **London,** 190

**Pola, Hydrographisches Amt der K. und K. Kriegs-Marine**

Veröffentlichungen, No. 11, 12.

(*The Office.*) 4to. **Pola,** 190

**Pola, Sebenico und Teodo:**

**Meteorologische Termin-Beobachtungen. May 1901—Apri** 1902.

(*The Office.*) obl. fol. **Wien,** 1901–190

**Popular Astronomy.** Edited by W. W. **Payne and H. C** Wilson. Vol. 9, 10. (No. 86–95.)

(*Editors.*) 8vo. Northfield, **Minn.,** 1901–190

**Potsdam, Centralbureau der Internationalen Erdmes sung:**

Veröffentlichungen, Neue Folge, No. 4, 5.

(*The Bureau.*) 4to. **Berlin,** 190

4. Th. Albrecht. Anleitung zum Gebrauche des Zenittelskop auf den Internationalen Breitenstationen. 2te Ausgabe.
5. Bericht über die Thätigkeit des Centralbureaus, 1901.

**Potsdam, Königl. preussisches Geodätisches Institut:**

Veröffentlichung, Neue Folge, No. 4, 6, 7.

(*The Institute.*) 4to. and 8vo. **Berlin,** 1901–190

4. Jahresbericht des Directors, 1899–1900.
6. Jahresbericht des Directors, 1900–1901.
7. Astronomisch-geodätische Arbeiten. I Ordnung. Längendiff renz Potsdam-Pulkowa.

**Prague, K.K. Sternwarte:**

Magnetische und meteorologische Beobachtungen im Jahr 1900. Jahrgang 61 . . . herausgegeben von L. Weinek

(*Observatory.*) 4to. **Prag,** 190

**Pulkowa, Observatoire Central-Nicolas:**

——: Publications. . . . sous la direction de O. Backlund Série 2, Vol. 6, 8.

(*Observatory.*) 4to. St.-Pétersbourg, 1900–190

6. H. Romberg. Observations faites au cercle méridien.
8. M. Nyrén et A. Ivanof. Observations faites au cercle vertical.

——: Jahresbericht über die Thätigkeit der Kaiserliche Nicolai-Hauptsternwarte, 1900–1901.

(*Observatory.*) 8vo. St. Petersburg, 190

**Quaternions and Allied Systems of Mathematics, Insti tute for Promoting the Study of:**

List of members, President's address, &c.

(*C. J. Joly.*) 8vo. **Dublin,** 190

**Radcliffe (R. D.)**
A memoir of Thomas Glazebrook Rylands.
(*J. P. Rylands.*) 8vo. Exeter, 1901

**Rajna (Michele):**
* Sull' escursione diurna della declinazione magnetica à Milano in relazione col periodo delle macchie solari.
(*Author.*) 8vo. Milano, 1902

**Rees (John Krom):**
—— : *The minor planets.
(*Author.*) 8vo. New York, 1898
—— : * Observations of the meteors, November 13–16, 1901.
(*Author.*) 8vo. Northfield, Minn., 1902

**Renfer (H.):**
Die Definitionen der Bernoullischen Funktion, und Untersuchung der Frage welche von denselben für die Theorie die zutreffendste ist. Inaugural-Dissertation.
(*Berne University.*) 8vo. Bern, 1900

**Reuleaux (F.):**
Die Sprache am Sternenhimmel ; und Ost, West, Süd, Nord. Zwei Abhandlungen.
(*Turnor and Horrox Fund.*) 4to. Berlin, 1901

**Richmond, Surrey, National Physical Laboratory:**
* Report of the . . . Committee of the Royal Society . . . for the year 1900.
(*Laboratory.*) 8vo. London, 1901

**Riefler (S.):**
Das Nickelstahl-Compensationspendel.
(*Author.*) 8vo. München, 1902

**Rio de Janeiro, Observatorio:**
—— : Annuario . . . para o anno de 1901.
(*Observatory.*) 8vo. Rio de Janeiro, 1901
—— : Boletim mensal. 1900, 5–12 ; 1901, 1–6.
(*Observatory.*) 4to. Rio de Janeiro, 1900–1901

**Roberts (Alexander W.):**
—— : * On the orbits of the Algol variables *RR* Puppis and *V* Puppis.
(*Author.*) 8vo. Chicago, 1901
—— : * Certain considerations regarding Algol variation, with special reference to C. P. D. $-41°$, 4511.
(*Author.*) 8vo. Edinburgh, 1902

**Robinson (W. H.):**
Life in other worlds.
(*Author.*) 8vo. [Birmingham,] 1901

**Rome, Reale Accademia dei Lincei:**
Atti . . . Anno 298, 299 (1901–1902), Serie quinta. Ren
conti, Classe di scienze fisiche, matematiche e natur
Vol. 10, semestre 1, fasc. 11, 12—Vol. 11, semestre 1, fa
1–10.
(*Academy.*) 4to. Roma, 1901–19

**Rome, Reale Osservatorio del Collegio Romano:**
Memorie . . . pubblicate per cura del Direttore P. Tacchi
Serie 3, vol. 1, 2.
(*Observatory.*) 4to. Roma e Modena, 1899–19

**Rowland (Henry A.):**
* A preliminary table of solar spectrum wave-lengths.
(*Johns Hopkins University.*) 8vo. Chicago, 18

**Royer (Clémence):**
Histoire du Ciel. 2me édition.
(*Turnor and Horrox Fund.*) 8vo. Paris, 19

**Rugby School Natural History Society:**
Report . . . for the year 1901.
(*The School.*) 8vo. Rugby, 19

**San Fernando, Instituto y Observatorio de Marina:**
——: Almanaque Náutico para el año 1903.
(*Observatory.*) 4to. San Fernando, 19
—— : Eclipse total de Sol del 28 de Mayo de 1900.
(*Observatory.*) 4to. San Fernando, 19

**San Fernando, Observatorio:**
Carta Fotografica del Cielo. Zone −9°; eight charts.
(*Observatory.*)

**San Francisco, Astronomical Society of the Pacific:**
Publications, Vol. 13, 14 (No. 79–83).
(*Society.*) 8vo. San Francisco, 1901–19

**Schneidewin (Max):**
Der Sternenhimmel und seine Verkleinerer. Eine Strei
schrift an von Hartmann.
(*Turnor and Horrox Fund.*) 8vo. Berlin, 19

**Schorr (R.):**
Die Hamburger Sternwarte.
(*Author.*) 8vo. Hamburg, 19

**Schreiber (Johann):**
P. Christoph Scheiner, S.J., und seine Sonnenbeobac
tungen.
(*Haynald Observatory.*) 8vo. Münster, 19

**Schur (Wilhelm):**
*Beiträge zur Geschichte der Astronomie in Hannover.
(*Göttingen Observatory.*) 8vo. Berlin. 19

**Science Gossip.** Vol. 7, 1901: vol. 8, 1902.
(*Editor.*) 4to. London, 1901–19

**See (Thomas J. J.):**

—— : *Micrometrical measures of the equatorial diameter of Saturn and of his system of rings.
(*Author.*) 4to. Kiel, 1902

—— : *Observations of the diameters of the satellites of Jupiter, and of Titan, the principal satellite of Saturn.
(*Author.*) 4to. Kiel, 1902

—— : *Observations of the four brighter satellites of Saturn, made with the 26-inch refractor of the U.S. Naval Observatory, Washington.
(*Author.*) 4to. Kiel, 1901

—— : *On the probable mass and density of Mercury and on the general principles governing the densities of the four inner planets.
(*Author.*) 4to. Kiel, 1901

—— : *Preliminary investigation of the diameter of Mars.
(*Author.*) 4to. Kiel, 1901

—— : *Preliminary investigation of the probable diameters, masses and densities of those satellites which have measurable discs.
(*Author.*) 8vo. Northfield, Minn., 1901

—— : *Researches on the diameter of Jupiter made with the 26-inch refractor of the U.S. Naval Observatory, Washington.
(*Author.*) 4to. Kiel, 1901

—— : * Researches on the diameter of Mercury, made with the 26-inch refractor of the U.S. Naval Observatory, Washington.
(*Author.*) 4to. Kiel, 1901

**Seeliger (Hugo):**

*Ueber kosmische Staubmassen und das Zodiacallicht.
(*Author.*) 8vo. München, 1901

**Sirius:** Zeitschrift für populare Astronomie; Redakteur H. J. Klein. Band 34, Heft 6—Band 35, Heft 6.
(*Editor.*) 8vo. Leipzig, 1901–1902

**Southport, Fernley Observatory:**

Report and results of [meteorological] observations for the year 1901, by J. Baxendell.
(*Author.*) 4to. Southport, 1902

**Spitaler (Rudolf):**

Die periodischen Luftmassenverschiebungen und ihr Einfluss auf die Lagenänderungen der Erdachse (Breitenschwankungen.)
(*Author.*) 4to. Gotha, 1901

**Stockholm, Kongliga Svenska Vetenskaps Akademie:**

—— : Bihang till . . . Handlingar. Afdelning 1, Mathematik, Astronomi [&c.]. Bandet 26.
(*Academy.*) 8vo. Stockholm, 1901

**Stockholm, Kongliga Svenska Ve**
*continued.*

—— : *Lefnadsteckningar. Bandet 4,
(*Academy.*) 8v

**Stonyhurst College Observatory:**
Results of meteorological and magn
report and notes of the director, R
(*Observatory.*)

**Switzerland, Schweizerische Geodät**
Das Schweizerische Dreiecknetz.
Azimutmessungen.
(*The Commission.*)

**Sydney, Royal Society of New So**
Journal and Proceedings for 1900.
(*Society.*)

**Tachkent, Observatoire Astronomiq**
Publications. No. 3.
(*Observatory.*) 4to.
W. Stratonoff. Études sur la structure
[texte et atlas].

**Tacubaya, Observatorio Astronómi**
Anuario . . . para el año de 1902.
(*Observatory.*)

**Tebbutt (John):**
Report of Mr. Tebbutt's Observator
sor, New South Wales, 1898, 190
(*Author.*)

**Thirion (J.):**
L'évolution de l'astronomie chez les
(*Turnor and Horrox Fund.*)

**Tiflis, Physikalisches Observatorium**
Beobachtungen . . . im Jahre 1898.
(*Observatory.*)

**Tinsley (G. W.):**
The mechanics of a thunderstorm.
(*Author.*)

**Toronto, Astronomical and Physical**
Transactions . . . for the years 190
and 12th Annual Reports.
(*Society.*) 8

**Toronto, Canadian Institute:**
Transactions. Vol. 7, pt. 1 (No. 13)
(*Institute.*)

**Toulouse, Académie des Sciences, Inscriptions et Belles-lettres:**
Bulletin et Mémoires. Tome 3.
(*Academy.*) 8vo. Toulouse, 1900

**Toulouse, Observatoire Astronomique, Magnétique et météorologique:**
Annales . . . . Tome 4 . . . sous la direction de B. Baillaud.
(*Observatory.*) 4to. Toulouse et Paris, 1901

**Towne (Gélion):**
Astronomie astrophysique, Géodésie, Topographie et Photogrammétrie pratique.
(*Turnor and Horrox Fund.*) 2 vols. 12mo. Paris, 1896

**Truro, Royal Institution of Cornwall:**
Journal, Vol. 14, pt. 1, 2. 1900, 1901.
(*Institution.*) 8vo. Truro, 1900–1901

**Turin, Reale Accademia delle Scienze:**
—— : Atti, Vol. 36, No. 6—Vol. 37, No. 10.
(*Academy.*) 8vo. Torino, 1901–1902
—— : Memorie, Serie seconda. Tomo 51.
(*Academy.*) 4to. Torino, 1902

**Turner (Herbert Hall):**
—— : *On the brightness of the corona of January 22, 1898. Preliminary note.
(*Author.*) 8vo. London, 1901
—— : *Note on the accuracy of the star charts published by the French observatories as reproductions of their plates for the Astrographic Chart.
(*Author.*) 8vo. London, 1901
—— : *Formulæ and tables for connecting co-ordinates of stars on different photographs, especially different plates of the Astrographic Chart.
(*Author.*) 8vo. London, 1901
—— : *On mechanically compensating the rotation of the field of a siderostat.
(*Author.*) 8vo. London, 1901

**Upsala, Kongliga Vetenskaps Societet:**
Nova Acta Regiæ Societatis Scientiarum Upsaliensis. Series 3, Vol. 19; vol. 20, fasc. 1.
(*Society.*) 4to. Upsaliæ, 1901

**Valentiner (Wilhelm):**
Handwörterbuch der Astronomie. Lieferung 26.
(*Turnor and Horrox Fund.*) 8vo. Breslau, 1901

**Very (Frank W.):**
*The solar constant.
(*Author.*) 8vo. Washington, 1901

**Vienna, Kaiserliche Akademie der Wissenschaften:**
—— : Denkschriften . . . Mathematisch-naturwissenschaftlic Classe. Band 66, pt. 3 ; 68.
(*Academy.*) 4to. Wien, 19
—— : Sitzungsberichte . . . Mathematisch-naturwissenschaftlic Classe. Abtheilung II.a., Mathematik, Astronom Physik, Meteorologie, Mechanik. Band 108–110, Heft
(*Academy.*) 8vo. Wien, 1899–19

**Vienna, K. und K. Militär-geographisches Institut:**
Astronomische-geodätische Arbeiten. Band 17.
(*Institute.*) 4to. Wien, 19
Polhöhen u. Azimuth-Messungen.

**Vienna, von Kuffner'sche Sternwarte:**
Publicationen . . . herausgegeben von Leo de Ball. Band Theil 1.
(*Herr von Kuffner.*) 4to. Wien, 19

**Virginia University, Leander McCormick Observatory:**
Publications: Ormond Stone, Director. Vol. 2, part 1.
(*Observatory.*) 8vo. Charlottesville, 19

**Vogel (H. C.):**
—— : *Weitere Untersuchungen über das spectroskopisch Doppelsternsystem Mizar.
(*Author.*) 8vo. Harlem, 19
—— :* Über die Bewegung des Orionnebels im Visionsradius.
(*Author.*) 8vo. Berlin, 19

**Walter (Albert):**
*On the origin and propagation of cyclonic storms.
(*Author.*) 8vo. Mauritius, 19

**Washburn Observatory of the University of Wisconsin:**
Publications. Vol. 10, part 2.
(*Observatory.*) 4to. Madison, Wis., 19
G. C. Comstock. Observations of Eros, 1900–1901.

**Washington, Navy Department:**
The American Ephemeris and Nautical Almanac, 1905.
(*American Ephemeris Office.*) 8vo. Washington, 19

**Washington, Philosophical Society:**
Bulletin. Vol. 13 ; Vol. 14, pp. 1–204.
(*Society.*) 8vo. Washington, 1900–19

**Washington, Smithsonian Institution:**
—— : Annals of the Astrophysical Observatory of th Smithsonian Institution. Vol. 1. By S. P. Langley Director.
(*Institution.*) 4to. Washington. 19
—— : Annual Report of the Board of Regents, 1899–1900.
(*Institution.*) 8vo. Washington, 19

**Washington, Smithsonian Institution**—*continued.*

—— : Smithsonian Miscellaneous Collections. Vol. 41, No. 1258 : Vol. 42, 43.
(*Institution.*) 8vo. Washington, 1901

41, No. 1258. S. P. Langley and F. W. Very. On the cheapest form of light.

43. W. J. Rhees. History and origin of the Smithsonian Institution.

—— : Smithsonian Contributions to Knowledge. No. 1309.
(*Institution.*) 4to. Washington, 1901

**Washington, United States Naval Observatory :**
Report of the Superintendent . . . for the year ending June 30, 1901.
(*Observatory.*) 8vo. Washington, 1901

**Waterhouse (Major-Gen. James) :**
*Notes on the early history of the Camera Obscura.
(*Author.*) 8vo. London, 1901

**Waugh (W. R.) :**
*Notes on some of the markings on Jupiter.
(*Author.*) 8vo. Dorchester, 1901

**Wilson (William E.) :**
*The effective temperature of the Sun.
(*Author.*) 8vo. London, 1902

**Wislicenus (Walter F.) :**
Astronomischer Jahresbericht ; mit Unterstützung der Astronomischen Gesellschaft herausgegeben von W. F. W. . . . Band 3, enthaltend die Literatur des Jahres 1901.
(*Editor.*) 8vo. Berlin, 1902

**Wolf (Max.) :**
*Die Entdeckung und Katalogisirung von kleinern Nebelflecken durch die Photographie.
(*Author.*) 8vo. München, 1901

**Zeitschrift für Instrumentenkunde**: Organ für Mittheilungen aus dem gesammten Gebiete der wissenschaftlichen Technik. Jahrgang 21, Heft 6—Jahrg. 22, Heft 5.
(*Turnor and Horrox Fund.*) 4to. Berlin, 1901–1902

**Zenger (Carl Venceslas) :**
Die Meteorologie der Sonne und das Wetter im Jahre 1890 ; zugleich Wetterprognose für die Jahre 1900 u. 1910.
(*Author.*) 8vo. Prag, 1901

**Zürich, Naturforschende Gesellschaft :**
Vierteljahrsschrift, Jahrgang 46, Heft 1–4.
(*Society.*) 8vo. Zürich, 1901–1902

**Zürich, Schweizerische meteorologische Centralanstalt :**
Annalen, 1899. Jahrgang 36.
(*Institute.*) 4to. Zürich, 1901

## PHOTOGRAPHS, &c., PRESENTED TO THE SOCIETY

**Brett (Mrs.)**—Astronomical drawings made by the la John Brett, F.R.A.S.

**Perth Observatory, West Australia**—Photographs of th Great Comet of 1901. (7 lantern slides.)

**Post (Mr. C. A.) and Prof. Rees**—Views of observatory, an two photographs of Leonid Meteor. (4 lantern slides.)

# ROYAL ASTRONOMICAL SOCIETY.

## LIST OF FELLOWS AND ASSOCIATES.

JUNE 1900.




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Astronomy and Geometry, Cambridge.

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G. H. Darwin, Esq. M.A. LL.D. F.R.S. Plumian P
Astronomy, Cambridge.

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Astronomy, Oxford.

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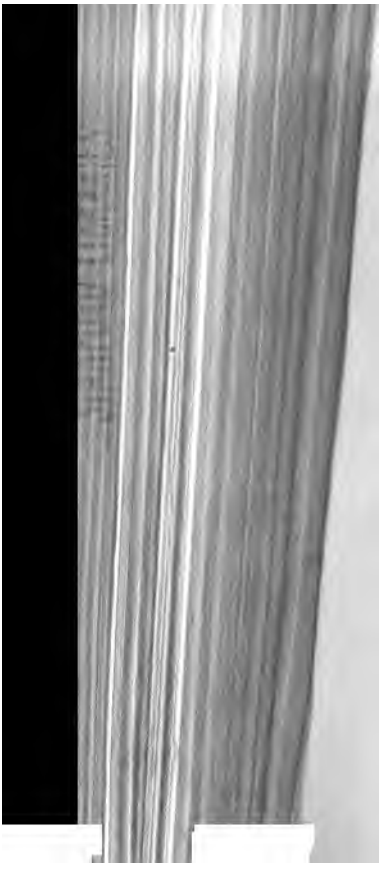
## JUNE 1900.

An asterisk (*) prefixed to a name indicates that the member has compounded

The present addresses of the following Fellows are not known, and the Secretaries would be glad of any information which would enable them to be traced :

| | LAST KNOWN ADDRESS. |
|---|---|
| *J. Owen Corrie ... ... | 131 Denmark Terrace, Brighton. (1896 June.) |
| *Isaac Engelson ... ... | Pomme d'Or, Jersey. (1897 Nov.) |
| Capt. J. Fisher ... ... | Kentmere, Birdhurst Rise, South Croydon. (1897 Nov.) |
| Rev. James H. Honeyburne, | 70 Devonshire Rd., Princes Park, Liverpool. (1898 Dec.) |
| *D. Lindsay Lowson ... | 164 Kennington Road, S.E. (1883 June.) |
| *Harris C. L. Saunders ... | 95 Queen's Gate, S.W. (1900 April.) |

| | | |
|---|---|---|
| 1893 Mar. 10 | Maur. Anderson | Ainslie, R.N. B.A., *H.M.S. 'Hannibal,' Channel Squadron.* |
| 1896 Jan. 10 | * Hugh Lancelot | Aldis, 65 *Lauderdale Mansions, Maida Vale, W.* |
| 1885 Mar. 13 | * Wm. Steadman | Aldis, M.A., *Kidlington, near Oxford.* |
| 1880 Nov. 12 | * Rev. Francis B. | Allison, M.A., *The Vicarage, Peasmarsh, Sussex.* |
| 1867 Nov. 8 | Thomas Michael | Almond, Port Master, *Brisbane, Queensland, Australia.* |
| 1854 Mar. 10 | Joseph Supino | Ancona, *Fernleigh, South Norwood, S.E.* |
| 1896 Apr. 10 | William | Anderson, *Quinta da Grevillea, Rua das Hortas, Funchal, Madeira.* |



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|---|---|
| 1873 Apr. 9 | * Thos. |
| 1888 Feb. 10 | Rev. |
| 1892 June 10 | Rev. |
| 1875 Mar. 12 | * Sir Ro |
| 1898 May 13 | George |
| 1896 May 8 | William |
| 1884 Nov. 14 | Pietro |
| 1899 Nov. 10 | Rev.Thos |
| 1895 Feb. 8 | Edwin |
| 1893 Feb. 10 | Samuel |
| 1874 May 8 | * Rev. H. G |
| 1888 Jan. 13 | * Edward E |
| 1879 May 9 | Capt. Edw |
| 1899 Apr. 14 | Ernest Will |
| 1881 May 13 | * John Alfred |
| 1863 Nov. 13 | Rev. J. Chad |
| 1880 Apr. 9 | * Lt.-Col.T |

| Date of Election. | | | |
|---|---|---|---|
| 1893 June 9 | | Hedley Robert | Beasley, 10 *Shear Bank Road;* and *Grammar School, Blackburn, Lancashire.* |
| 1877 May 11 | * | William Morris | Beaufort, F.R.G.S., 18 *Piccadilly, W.;* and *Athenæum Club, S.W.* |
| 1893 Apr. 14 | | Ludwig | Becker, Ph.D. F.R.S.E., Professor of Astronomy in the University of Glasgow, *Observatory, Glasgow.* |
| 1862 Apr. 11 | | Commr. James F. | Beckett, R.N., *Avondell, Hollington Park, St. Leonard's-on-Sea.* |
| 1896 Feb. 14 | | Frank Arthur | Bellamy, F.R.Met.Soc., *University Observatory;* and 4 *St. John's Road, Oxford.* |
| 1892 Feb. 12 | | Bertram | Bennett, M.A., *Montpelier, Paignton, South Devon.* |
| 1888 Mar. 9 | * | Arthur | Berry, M.A., *King's College, Cambridge.* |
| 1893 Jan. 13 | | Joseph Ibbitson | Berry, *Hazeldene, Avenue Road, Highgate, N.* |
| 1866 Nov. 9 | * | Rev. Frank | Besant, M.A., *Sibsey Vicarage, Boston, Lincolnshire.* |
| 1854 Feb. 10 | * | Wm. Henry | Besant, M.A. Sc.D. F.R.S., *St. John's College, Cambridge.* |
| 1890 Jan. 10 | | Algernon Sidney | Bicknell, *Barcombe House, Barcombe, Sussex.* |
| 1869 Jan. 8 | * | Lieut.-Col. A. C. | Bigg-Wither, *Tilthams, Godalming, Surrey.* |
| 1881 Jan. 14 | | Raphael Louis | Bischoffsheim, *Observatoire, Nice;* and 3 *rue Taitbout, Paris.* |
| 1875 Apr. 9 | | Lord | Blythswood, *Blythswood, near Renfrew, Scotland;* and 2 *Seamore Place, Curzon Street, W.* |
| 1894 Apr. 13 | | Lyndon | Bolton, B.A., *Patent Office, Southampton Buildings, Chancery Lane, W.C.* |
| 1888 Nov. 9 | | Thomas | Bolton, *Chowringhee, Wembley, N.W.* |
| 1894 Dec. 14 | | George Cox | Bompas, F.G.S. F.R.G.S., 121 *Westbourne Terrace, W.* |
| 1887 Apr. 6 | | Rev. John | Bone, *St. Thomas's Vicarage, Lancaster.* |
| 1871 Nov. 10 | * | Robt. Holford M. | Bosanquet, M.A. F.R.S., *Castillo Zamora, Realejo Alto, Teneriffe, Canary Islands.* |
| 1889 Jan. 11 | * | Henry Lord | Boulton, *Caracas, Venezuela, South America.* |
| 1895 Feb. 8 | | Vincent Joseph | Bouton, B.Sc., 9 *Lansdowne Terrace, Hampton Wick.* |
| 1867 Feb. 8 | * | Edward E. | Bowen, *Harrow School, Harrow-on-the-Hill.* |
| 1892 Dec. 9 | | John A. | Brashear, *Allegheny, Pennsylvania, U.S.A.* |
| 1893 Jan. 13 | | Martin | Brendel, Ph.D., Professor of Theoretical Astronomy and Geodesy in the University, 42 *Bühlstrasse, Göttingen, Germany.* |
| 1871 June 9 | | John | Brett, A.R.A., *Daisyfield, Putney Heath Lane, S.W.* |
| 1877 June 8 | * | Thomas Dalby | Brewin, *Burlington House,* 43 *St. Alban's Road, Leicester.* |



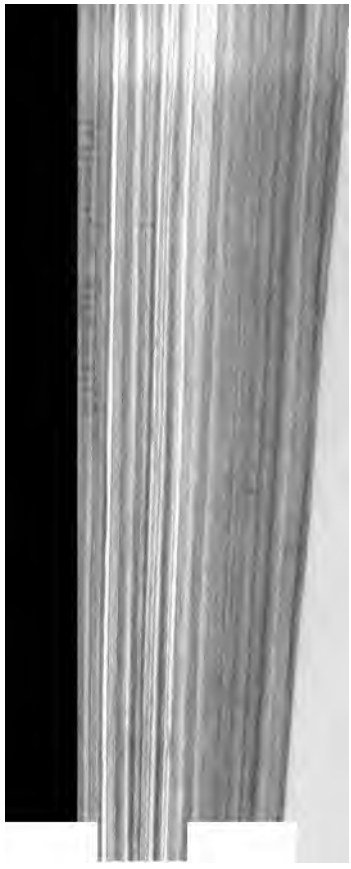
| | | |
|---|---|---|
| 1888 Feb. 10 | * | John Henry |
| 1891 Jan. 9 | * | James Stark |
| 1890 May 9 | | Thomas William |
| 1865 Mar. 10 | | John |
| 1887 Dec. 9 | | Hon. Justice Gal |
| 1882 Nov. 10 | * | Robert |
| 1892 Dec. 9 | * | Walter William |
| 1894 Jan. 12 | | John Harrison |
| 1896 June 12 | | Rev. Fredk. Lisle |
| 1892 Feb. 12 | | Charles |
| 1890 Jan. 10 | | Rev. George |
| 1897 Apr. 9 | | Rev. Sherrard B. |
| 1874 Nov. 13 | * | Sherburne W. |
| 1885 Apr. 10 | * | Major Sidney G. |
| 1865 Apr. 12 | * | Col. Alexander |
| 1900 Apr. 11 | | Thomas C. |
| 1871 May 12 | * | Reginald |

| Date of Election. | | |
|---|---|---|
| 1877 June 8 | * George | Calver, *Hill House, Widford, Chelmsford.* |
| 1889 May 10 | * Edward | Carpmael, B.A. Assoc. Inst. C.E., *The Ivies, St. Julian's Farm Road, West Norwood, S.E.* |
| 1873 Feb. 14 | * Ernest | Carpmael, M.A. Q.C., *Ferndale, Woodside Road, Sutton, Surrey.* |
| 1891 Jan. 9 | Edward Tremlett | Carter, Assoc. Inst. E.E., *Rose Bank, 40 Alexandra Road, Upper Norwood, S.E.* |
| 1896 Mar. 13 | * James | Cavan, M.A., *Eaton Mascott Hall, Shrewsbury.* |
| 1879 Nov. 14 | Rev. James Law | Challis, M.A., *The Vicarage, Stone, Aylesbury.* |
| 1864 Feb. 12 | George Fredk. | Chambers, *Northfield Grange, Eastbourne, Sussex.* |
| 1895 Jan. 9 | Lt.Col. W. St. L. | Chase, V.C. F.R.G.S., 7th Bombay Infantry, *Quetta, Beluchistan.* |
| 1899 Apr. 14 | Samuel | Chatwood, M.Inst.M.E. F.R.G.S., *Broadoak Park, Worsley, Manchester.* |
| 1871 Mar. 13 | * W. H. Mahoney | Christie, C.B. M.A. F.R.S., Astronomer Royal, PAST PRESIDENT, *Royal Observatory, Greenwich, S.E.* |
| 1891 Dec. 11 | Lord Edw. Spencer | Churchill, 28 *Grosvenor Street, W.* |
| 1897 Feb. 12 | John Charles | Clancey, F.R.G.S. F.S.I., Assistant Director of Land Records and Agriculture, *Rangoon, Burma.* |
| 1894 June 8 | Rev. John Thos. W. | Claridge, M.A., 3 *Albert Road, Tamworth, Staffordshire.* |
| 1900 Jan. 12 | Maurice Harvey | Clarke, Lieut. R.N.R. F.R.G.S., *Coleswood, Harpenden, Herts.* |
| 1896 Feb. 14 | Thomas Folkes | Claxton, Director of the Royal Alfred Observatory, *Mauritius.* |
| 1897 May 14 | Arthur W. | Clayden, M.A. F.G.S., *St. John's, Polsloe Road, Exeter.* |
| 1860 Apr. 13 | * Robert Bellamy | Clifton, M.A. F.R.S., Professor of Experimental Philosophy in the University of Oxford, 3 *Bardwell Road, Banbury Road, Oxford.* |
| 1859 Feb. 11 | John Francis | Cole, *Westfield, Cheam Road, Sutton, Surrey.* |
| 1853 June 10 | Everard Home | Coleman, 71 *Brecknock Road, Camden Road, N.* |
| 1884 Feb. 8 | * William | Coleman, *The Shrubbery, Buckland, Dover.* |
| 1881 Jan. 14 | John | Coles, *Royal Geographical Society,* 1 *Savile Row, W.;* and *Liphook, Hants.* |
| 1875 Nov. 12 | * John Brise | Colgrove, M.A., *Burton House, Loughborough.* |
| 1876 June 9 | * ANDREW AINSLIE | COMMON, LL.D. F.R.S., VICE-PRESIDENT, PAST PRESIDENT, 63 *Eaton Rise, Ealing, W.* |
| 1881 Jan. 14 | James | Cook, *University, Sydney, New South Wales.* |
| 1896 Jan. 10 | William Ernest | Cooke, M.A., *Observatory, Perth, West Australia.* |
| 1894 Dec. 14 | * Bryan | Cookson, *Oakwood, Wylam, R.S.O., Northumberland.* |

| Date of Election. | | | |
|---|---|---|---|
| 1888 Jan. 13 | * | Major Leonard | Darwin, R.E., 12 *Egerton Place, S.W.* |
| 1889 Mar. 8 | * | Rev. C. D. Percy | Davies, M.A., *East Marden Rectory, Chichester, Sussex.* |
| 1869 Mar. 12 | * | Rev. Robert P. | Davies, M.A., *Hatherop Rectory, Fairford, Gloucestershire.* |
| 1875 May 14 | * | Percy L. H. | Davis, '*Nautical Almanac*' *Office*, 3 *Verulam Buildings, Gray's Inn, W.C.* |
| 1889 Nov. 8 | * | Richard Evan | Day, M.A., 135 *Fellows Road, Hampstead, N.W.* |
| 1877 June 8 | | William Fredk. | Denning, 100 *Egerton Road, Bishopston, Bristol.* |
| 1895 Feb. 8 | | Henri | Deslandres, D. ès Sc., *Observatoire, Meudon*, and 56 *bis, Route des Gardes, Bellevue, Seine-et-Oise, France.* |
| 1899 Feb. 10 | | William Lee | Dickinson, M.D. F.R.C.P., 9 *Chesterfield Street, Mayfair, W.* |
| 1893 Jan. 13 | | Ernest Gould | Dixon, 9 *Westbourne Park Villas, W.* |
| 1897 Feb. 12 | * | William Fraser | Doak, M.A., '*Nautical Almanac*' *Office*, 3 *Verulam Buildings, Gray's Inn, W.C.* |
| 1893 Nov. 10 | | William Murray | Dobie, M.D. J.P., *Northgate House, Chester.* |
| 1898 Nov. 11 | | Cecil Goodrich Julius | Dolmage, M.A. LL.D. D.C.L., 22 *Upper Merrion Street, Dublin.* |
| 1898 Mar. 11 | | Eric | Doolittle, B.Sc., *Flower Observatory, University of Pennsylvania, Philadelphia, Pa., U.S.A.* |
| 1898 Nov. 11 | | Andrew Ellicott | Douglass, B.A., *Lowell Observatory, Flagstaff, Arizona, U.S.A.* |
| 1875 Mar. 12 | | Arthur M. W. | Downing, M.A. D.Sc. F.R.S., Superintendent of the 'Nautical Almanac,' 3 *Verulam Buildings, Gray's Inn, W.C.;* and 74 *Vanbrugh Park, Blackheath, S.E.* |
| 1893 Feb. 10 | | Patrick | Doyle, F.R.S.E. M.R.I.A., 19 *Lall Bazar Street, Calcutta, India.* |
| 1868 Jan. 10 | | Major-Gen. A. W. | Drayson, R.A., 20 *Ashburton Road, Southsea;* and *Royal Alfred Yacht Club, Southsea, Hants.* |
| 1875 Mar. 12 | | John L. E. | Dreyer, Ph.D., *Observatory, Armagh, Ireland.* |
| 1888 Apr. 13 | | John Edmund | Drower, *Warwick House, Mount Ephraim Road, Streatham, S.W.* |
| 1894 Nov. 9 | | Major Archd. S. | Drummond, 117 *Ashley Gardens, S.W.;* and *Guards' Club, Pall Mall.* |
| 1889 Nov. 8 | | Philip Freeling | Duke, *Hendon, Middlesex.* |
| 1882 Dec. 8 | | Hon. Cecil | Duncombe, *The Grange, Nawton, R.S.O., North Yorkshire.* |
| 1876 Mar. 10 | | John William | Durrad, 39 *St. Peter's Road, Leicester.* |
| 1877 Jan. 12 | | Rev. Daniel | Dutton, F.G.S., *The Manse, Caversham, Dunedin, New Zealand.* |

| Date of Election. | | | |
|---|---|---|---|
| 1894 Apr. 13 | * | Frank Watson | Dyson, M.A., Sec<br>*Greenwich, S.*<br>*Blackheath, S.* |
| 1880 May 14 | | Lindsay Atkins | Eddie, *Oatlands,*<br>*Hope.* |
| 1894 May 11 | | Rev. Fras. John | Eld, M.A., *Polstea* |
| 1859 July 8 | | Robt. Lewis John | Ellery, C.M.G. F.I |
| 1893 June 9 | | Edwin Bailey | Elliott, M.A. F.R.I<br>Mathematics :<br>lege, 4 *Bardw* |
| 1898 June 10 | * | Henry | Ellis, *Ingleficld,*<br>*Middlesex.* |
| 1864 Dec. 9 | * | William | Ellis, F.R.S. F.R.<br>*Blackheath, S.* |
| 1872 Feb. 9 | * | Isaac | Engelson. (*No ad* |
| 1872 Feb. 9 | * | J. Kennedy | Esdaile, M.A.,<br>*Sussex.* |
| 1878 Jan. 11 | | Rev. T. H. E. C. | Espin, M.A., *W*<br>*Law, R.S.O.,* |
| 1898 May 13 | | Edward Iszatt | Essam, *Billingbo* |
| 1863 Feb. 13 | * | William | Esson, M.A. F.R.<br>of Geometry, |
| 1895 Feb. 8 | | Chas. Roberts D' | Esterre, 26 *Wellii* |
| 1858 Mar. 12 | * | Rev. Charles | Evans, M.A., *St.*<br>*Dorset.* |
| 1882 June 9 | | Franklen George | Evans, J.P., F.R.I<br>*ton, near Carc* |
| 1886 Jan. 8 | | Joseph Edward | Evans, B.A., *Q*<br>*School, Green* |
| 1896 Nov. 13 | | Lewis | Evans, J.P. F.I<br>*Langley, Hert* |
| 1894 Jan. 12 | * | John | Evershed, Jun., *A* |
| 1900 Jan. 12 | | Rev. Paul Wynyard | Fairclough, *Tri*<br>*Zealand.* |
| 1887 Dec. 9 | * | Lord | Farnham, *Farnh* |
| 1858 Dec. 10 | | Rev. Adam Storey | Farrar, D.D., *Th* |
| 1889 Jan. 11 | * | Samuel | Fellows, *Tynwal*<br>*Wolverhampto* |
| 1895 June 14 | * | John A. | Ferguson, 1 and<br>*Colorado, U.S* |
| 1887 June 10 | | Capt. A. Mostyn | Field, R.N., *Bron* |

| Date of Election. | | | |
|---|---|---|---|
| 1900 June 8 | | Louis Napoleon Geo. | Filon, M.A., Fellow of and Assistant Professor of Applied Mathematics at University College, London, *King's College, Cambridge*, and *Godwin House, St. Augustine's Road, South Croydon.* |
| 1893 Mar. 9 | * | Gerard Brown | Finch, M.A., 1 *St. Peter's Terrace, Cambridge.* |
| 1873 Nov. 14 | * | Wm. Henry | Finlay, M.A., *Observatory Road, Cape Town, S. Africa.* |
| 1864 May 13 | | Henry Philip | Finlayson, *Avenue Villas, Frith Road, Dover.* |
| 1890 Nov. 14 | * | Hon. Justice Robert Isaac | Finnemore, J.P. F.R.Hist.S., *Supreme Court, Pietermaritzburg, Natal.* |
| 1883 Dec. 14 | | Maj. C. Hawkins | Fisher, *The Castle, Stroud, Gloucestershire.* |
| 1892 Dec. 9 | | Capt. James | Fisher. (*No address: see slip.*) |
| 1887 Jan. 14 | | Shelley | Fisher, 48 *Primrose Mansions, Prince of Wales Road, Battersea Park, S.W.* |
| 1891 May 8 | | Alfred Henry | Fison, D.Sc. *University College, Gower Street, W.C.*; and 25 *Blenheim Gardens, Willesden Green, N.W.* |
| 1878 Apr. 12 | | Camille | Flammarion, *rue Cassini* 16, *Avenue de l'Observatoire, Paris*; and *Observatoire de Juvisy, Seine-et-Oise, France.* |
| 1878 Jan. 11 | | Rev. David | Fleming, *Vicarage, Coxhoe, R.S.O., Co. Durham.* |
| 1900 May 11 | * | Alexander | Foote, J.P. F.S.A.Scot., 111 *Warwick Road, Earl's Court, S.W.*; and *Mall Park, Montrose, Scotland.* |
| 1884 Apr. 9 | | Capt. Duncan | Forbes, 169 *High Street, Southampton.* |
| 1873 Jan. 10 | * | George | Forbes, M.A. F.R.S. M.Inst.C.E. M.Inst.E.E., 34 *Great George Street, Westminster, S.W.* |
| 1898 May 13 | * | Hon. Geo. Stuart | Forbes, H.M. India Civil Service, *Ootacamund, Madras Presidency, India.* |
| 1893 Mar. 10 | | James Arthur | Formoy, F.C.S., *Chestham, Grange Road, Sutton, Surrey.* |
| 1895 May 10 | * | Andrew Russell | Forsyth, M.A. Sc.D. LL.D. F.R.S., Sadlerian Professor of Pure Mathemntics, *Trinity College, Cambridge.* |
| 1895 Dec. 13 | | Major Kingsley O. | Foster, J.P., *Shenley, Redhill, Surrey.* |
| 1889 Dec. 13 | * | Alfred | Fowler, *Royal College of Science, South Kensington*, and 7 *Cortayne Road, Fulham, S.W.* |
| 1896 Jan. 10 | | Alpin G. | Fowler, M.Inst.C.E., 1 *Cambridge Road, Norbiton, Surrey.* |
| 1851 June 13 | * | William | Francis, Ph.D. F.L.S. F.C.S., *care of Taylor & Francis, Red Lion Court, Fleet Street, E.C.* |
| 1897 Apr. 9 | * | John | Franklin-Adams, *Grange Cottage, Wimbledon*; and *Machrihanish House, Campbeltown, Scotland.* |
| 1880 Jan. 9 | * | William Sadler | Franks, *care of Isaac Roberts, F.R.S., Starfield, Crowborough, Sussex.* |

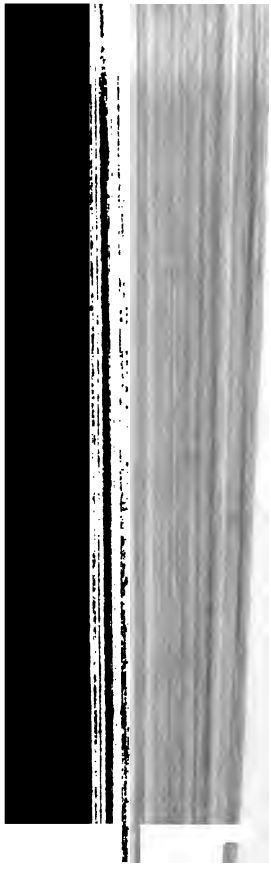


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|---|---|
| | Rev. Ed |
| 1870 Jan. 14 | * William |
| 1870 May 13 | * Charles |
| 1872 Dec. 13 | * Edward |
| 1894 Nov. 9 | S. Maitla |
| 1894 Mar. 9 | Augustin |
| 1900 Jan. 12 | * Umes Cha |
| 1892 Mar. 11 | Arthur |
| 1857 Jan. 9 | William Bo |
| 1867 Dec. 13 | * Sir David |
| 1888 Jan. 13 | James |
| 1841 May 14 | * James |
| 1871 Apr. 14 | * J. W. L. |
| 1874 May 8 | * Joseph |
| 1893 Apr. 14 | * Raymond Hil |
| 1885 Jan. 9 | Walter |
| 1889 Jan. 11 | * John Jas. Lev |

| Date of Election. | | | |
|---|---|---|---|
| 1896 April 10 | | Frank L. | Grant, M.A., 58 *Kelvingrove Street, Glasgow, Scotland.* |
| 1895 Jan. 11 | | Charles Josephus | Green, M.R.C.S. L.S.A., 10 *St. Paul's Square, Preston, Lancashire.* |
| 1896 Nov. 13 | * | John Anderton | Greenwood, B.A. LL.M., *Funtington House, near Chichester, Sussex.* |
| 1890 Feb. 14 | | Richard A. | Gregory, *The Homestead*, 19 *Westover Road, Wandsworth Common, S.W.* |
| 1898 Jan. 14 | | Edward John | Griffin, Commr. R.N.R., *Union Steamship Company, Shanghai, China.* |
| 1878 Feb. 8 | | John E. | Griffith, *Bryn Dinas, Upper Bangor, North Wales.* |
| 1866 Nov. 9 | * | Lord | Grimthorpe, M.A. LL.D. Q.C., 33 *Queen Anne Street, W.* |
| 1870 Nov. 11 | | Sir Howard | Grubb, F.R.S. M.I.C.E.I., Honorary Master of Engineering, University of Dublin, 51 *Kenilworth Square, Rathgar, Dublin.* |
| 1891 Jan. 9 | * | Rev. H. Grattan | Guinness, D.D. F.R.G.S., *Harley House, Bow, E.;* and *Cliff House, Curbar, viâ Sheffield.* |
| 1873 Nov. 14 | | Col. Gardiner F. | Guyon, Commanding 7th Regimental District, *Egerton House, Richmond, Surrey.* |
| 1879 May 9 | * | George Thorn | Gwilliam, 82 *Honeywell Road, New Wandsworth, S.W.* |
| 1896 Jan. 10 | | David Edward | Hadden, *Alta, Buena Vista Co., Iowa, U.S.A.* |
| 1891 May 8 | * | George E. | Hale, D.Sc., Director of the Yerkes Observatory, *Williams Bay, Wisconsin, U.S.A.* |
| 1878 Mar. 8 | * | Rev. Frederic J. | Hall, M.A., *Northaw Place, Potter's Bar, Hertford.* |
| 1899 Feb. 10 | | John James | Hall, *Observatory Cottage, Datchet Road, Slough, Bucks.* |
| 1878 May 10 | | Maxwell | Hall, M.A., *Montego Bay, Jamaica;* and *care of Miss Hall*, 10 *Osborne Road, Clifton, Bristol.* |
| 1891 Feb. 13 | | G. P. Blackwood | Hallowes, 48 *Queen Anne's Road, York.* |
| 1895 Jan. 11 | | Frederic | Hammond, F.R.I.B.A., 38 *Mercers Road, Upper Holloway, N.* |
| 1892 Nov. 11 | | Herbert | Hancock, M.A. F.R.Met.Soc., *Hipperholme Grammar School, Halifax, Yorks.* |
| 1899 Jan. 13 | | Arthur | Hands, M.R.C.S., L.R.C.P., *Inkerman House, Wednesfield Road, Wolverhampton.* |
| 1882 Jan. 13 | * | Rev. Thomas | Hands, M.A., *St. Laurence's Vicarage, Northampton.* |
| 1877 Feb. 9 | | George Francis | Hardy, 36 *Bloomsbury Square, W.C.* |
| 1854 Jan. 13 | * | Rev. Robert | Harley, M.A. F.R.S., *Rosslyn, Westbourne Road, Forest Hill, S.E.* |

| Date of Election. | | | |
|---|---|---|---|
| 1883 Apr. 13 | | Rev. Timothy | Harley, *The Torrs, Wallington, Surrey.* |
| 1895 Jan. 11 | | William | Harnett, 23 *Thornton Hill, Wimbledon.* |
| 1890 Feb. 14 | | Alfred Newton | Harris, 5 *Clarendon Place, The Hoe, Plymouth.* |
| 1882 Jan. 13 | | Jasper Nicolls | Harrison, *Saling Grove, Braintree, Essex.* |
| 1899 Jan. 13 | | Samuel Henry | Harrison, F.R.G.S., *Frederick Road, Edgbaston, Birmingham.* |
| 1879 May 9 | | John Penn | Hartree, M.A. M.B., *Oaklands, Langton, Tunbridge Wells.* |
| 1900 Jan. 12 | | Richd. Kilvington | Hattersley, F.R.G.S., 4 *Church Terrace, Blackheath, S.E.* |
| 1878 Feb. 8 | | Henry Burdett | Hederstedt, C.E. F.R.G.S., *Lucknow, India;* and *Twyford Lodge, Southlands Road, Bickley, Kent.* |
| 1885 Jan. 9 | | Rev. Andrew | Henderson, LL.D., *Castlehead, Paisley, Scotland.* |
| 1890 May 9 | * | Lt.-Col. George | Henderson, M.R.A.S. F.S.A.Scot. F.R.S.North Antiq., *Ovenden, Sevenoaks, Kent.* |
| 1890 Feb. 14 | | Fredk. William | Henkel, B.A., *Markree Observatory, Collooney, Co. Sligo, Ireland.* |
| 1864 Feb. 12 | | John B. N. | Hennessey, C.I.E. M.A. F.R.S. F.R.G.S., 18 *Alleyn Park, West Dulwich, S.E.;* and *Athenæum Club, S.W.* |
| 1887 Apr. 6 | | Capt. M. W. C. | Hepworth, 60 *Mattock Lane, Ealing Dean, N.W.* |
| 1897 Mar. 12 | | J. Harold | Herbert, *Hazelmont, The Boulevard, Nottingham.* |
| 1867 Mar. 8 | * | Prof. Alex. Stewart | Herschel, M.A. D.C.L. F.R.S., *Observatory House, Slough, Bucks.* |
| 1872 Feb. 9 | * | Col. John | Herschel, R.E. F.R.S., Member of Senate, Calcutta University; *Observatory House, Slough, Bucks.* |
| 1890 Nov. 14 | | George | Higgs, 320 *West Derby Road, Liverpool.* |
| 1893 Dec. 8 | * | Captain Edm. H. | Hills, R.E., 32 *Prince's Gardens, S.W.* |
| 1899 Jan. 13 | * | Arthur Robert | Hinks, M.A., *Observatory, Cambridge;* and 10 *Huntingdon Road, Cambridge.* |
| 1891 Feb. 13 | * | Shin | Hirayama, *The Observatory, Azabu, Tokyo, Japan.* |
| 1895 Mar. 8 | | George Denton | Hirst, 379 *George Street, Sydney, New South Wales, Australia.* |
| 1895 June 14 | | Ernest William | Hobson, Sc.D. F.R.S., *Christ's College, Cambridge.* |
| 1878 Mar. 8 | | William | Hobson, *Liscelta, Burnaby Estate, Greystones, Co. Wicklow, Ireland.* |
| 1895 Mar. 8 | | Samuel V. | Hoffman, 91 *Madison Avenue, Morristown, New Jersey, U.S.A.* |
| 1890 Nov. 14 | | Neville | Holden, *Queen Square, Lancaster.* |
| 1884 Dec. 12 | | Henry Park | Hollis, B.A., *Royal Observatory, Greenwich;* and 2 *Foyle Road, Blackheath, S.E.* |
| 1868 June 12 | | Henry William | Hollis, *Fairfield, Darlington.* |
| 1885 Apr. 10 | | Rev. James Hardy | Honeyburne, M.A. (*No address: see slip.*) |
| 1879 Mar. 14 | * | Maures | Horner, Mells, Frome, Somerset. |

| Date of Election. | | | |
|---|---|---|---|
| 1884 Apr. 9 | | Charles | Horsley, M.Inst.C.E. F.G.S., 174 *Highbury New Park, N.* |
| 1873 Dec. 12 | * | Joseph | Hough, M.A., *Codsall Wood, near Wolverhampton.* |
| 1899 Nov. 10 | * | Sydney Samuel | Hough, M.A., *Royal Observatory, Cape of Good Hope.* |
| 1881 Jan. 14 | | Elijah | Howarth, *Public Museum, Weston Park, Sheffield.* |
| 1861 Mar. 8 | | Rev. Frederick | Howlett, M.A., 7 *Princes Buildings, Clifton, Bristol.* |
| 1898 Feb. 11 | * | Thomas Charlton | Hudson, B.A., '*Nautical Almanac*' *Office*, and 37 *Lambton Road, Hornsey Rise, N.* |
| 1854 Apr. 12 | * | Sir WILLIAM | HUGGINS, K.C.B. D.C.L. LL.D. Ph.D. D.Sc. F.R.S., FOREIGN SECRETARY, PAST PRESIDENT, 90 *Upper Tulse Hill, S.W.* |
| 1898 Feb. 11 | | David | Hunter, *St. Ronan's, Lanark, Scotland.* |
| 1885 Dec. 11 | | James | Hunter, F.R.C.S.E. F.R.P.S. F.R.S.E., *Rosetta, Liberton, Midlothian, Scotland.* |
| 1886 Dec. 10 | | Rev. Robt. Sparke | Hutchings, *The Vicarage, Alderbury, Salisbury.* |
| 1887 Jan. 14 | | Cuthbert | Hutchinson, *Rock Lodge, Roker, near Sunderland.* |
| 1879 Jan. 10 | | Robert T. A. | Innes, *Royal Observatory, Cape of Good Hope.* |
| 1874 Nov. 13 | * | Lord | Inverclyde, *Castle Wemyss, Wemyss Bay, Greenock, Scotland.* |
| 1861 Feb. 8 | * | Richard | Inwards, 20 *Bartholomew Villas, Kentish Town, N.W.* |
| 1888 Jan. 13 | * | George James | Jacobs, *Lansdowne, Guildford, Surrey.* |
| 1890 Nov. 14 | | Harold | Jacoby, B.A. Ph.D., Adjunct Professor of Astronomy, *Astronomical Observatory, Columbia University, New York City, U.S.A.* |
| 1892 May 13 | * | Otto | Jaffe, 10 *Donegall Square South, Belfast, Ireland.* |
| 1898 Mar. 11 | | Rev. Kingsbury | Jameson, M.A., *Highfield, Hendon.* |
| 1891 Jan. 9 | | Charles W. H. | Jeavons, *Horseley Place, Tipton, Staffordshire.* |
| 1878 Nov. 8 | | Benjamin George | Jenkins, 43 *Chatsworth Road, West Dulwich, S.E.* |
| 1894 Apr. 13 | | Griffith Parry | Jenkins, *National Provincial Bank, Colwyn Bay, North Wales.* |
| 1892 May 13 | | Charles Henry | Johns, M.A., 39 *Choriton Gardens, Folkestone.* |
| 1888 May 11 | | Rev. Alfred Robt. | Johnson, M.A., *Salutary Mount, Heavitree, Exeter.* |
| 1876 Jan. 14 | | Richard Coward | Johnson, 46 *Jermyn Street, Liverpool.* |
| 1872 Mar. 8 | * | Rev. Samuel J. | Johnson, M.A., *The Vicarage, Melplash, R.S.O., Bridport, Dorset.* |
| 1884 June 13 | * | S. Wellesley | Johnson, M.B., R.N., *H.M.S.* '*Liffey*,' *Coquimbo, Chile, South America.* |

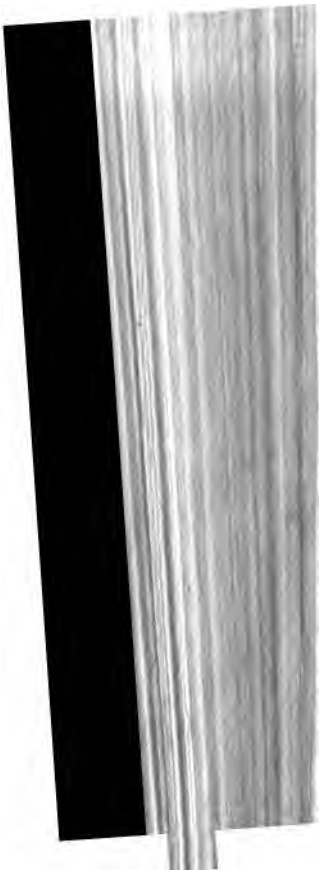


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|---|---|---|
| 1894 Jan. 12 | Joshua | |
| 1890 Mar. 14 | * James Edward | |
| 1894 Apr. 13 | Wm. Redfern | |
| 1868 Nov. 13 | * Lord | |
| 1893 May 12 | Rev. Philip H. | |
| 1891 Mar. 13 | Arthur | |
| 1893 June 9 | * Arthur E. | ] |
| 1864 Jan. 8 | * David Joseph | ] |
| 1896 Jan. 10 | Rev. Robert | ] |
| 1859 May 13 | Rev. Samuel | F |
| 1881 Jan. 14 | * Sydney T. | F |
| 1896 Jan. 10 | George Handley | K |
| 1878 Jan. 11 | Lt.-Col. H.S.G.S. | K |
| 1896 Mar. 13 | Thomas Edward | Kr |

| Date of Election. | | | |
|---|---|---|---|
| 1870 Apr. 8 | * | Carlton John | Lambert, M.A., *Royal Naval College, Greenwich, S.E.* |
| 1874 May 8 | | William James | Lancaster, F.C.S. F.G.S. F.R.M.S., *Colmore Row, Birmingham.* |
| 1895 Feb. 8 | | George Darley | Lardner, *Claraville, Felpham, Sussex.* |
| 1899 Feb. 10 | * | Joseph | Larmor, M.A. D.Sc. F.R.S., *St. John's College, Cambridge.* |
| 1873 Jan. 10 | * | Edwin | Lawrence, 13 *Carlton House Terrace, S.W.* |
| 1888 Nov. 9 | * | Arthur Herbert | Leahy, M.A., *Firth College, Sheffield.* |
| 1900 May 11 | | Désiré Ernest | Lebon, Agrégé de l'Université, Professeur de Mathématiques au Lycée Charlemagne, 4 *bis, rue des Écoles, Paris.* |
| 1876 Feb. 11 | * | Rev. Edmund | Ledger, M.A., *Protea, Reigate, Surrey.* |
| 1869 Feb. 12 | * | John | Lee, *St. Peter's Chambers, Cornhill, E.C.* |
| 1892 Jan. 8 | | Edward Herbert | Lees, *Fairhaven, Mallacoota, East Gippsland, Victoria, Australia.* |
| 1894 Jan. 12 | | Henry Alfred | Lenehan, *Government Observatory, Sydney, New South Wales, Australia.* |
| 1855 Feb. 9 | | William | Lethbridge, *Courtlands, Lympstone, Devon.* |
| 1894 Jan. 12 | | Armin Otto | Leuschner, B.A. Assistant Professor of Astronomy in the University of California, *Berkeley, California, U.S.A.* |
| 1871 Mar. 10 | | Fredk. Wm. | Levander, 30 *North Villas, Camden Square, N.W.* |
| 1897 Feb. 12 | | Rev. Edw. Spry | Leverton, M.A., *The School House, Kirkham, Lancashire.* |
| 1884 Dec. 12 | | Thomas | Lewis, *Royal Observatory, Greenwich, S.E.* |
| 1873 Feb. 14 | * | William J. | Lewis, Professor of Mineralogy in the University of Cambridge, *Mineralogical Museum, Cambridge.* |
| 1873 Feb. 14 | * | Adolph F. | Lindemann, *Sidholme, Sidmouth, Devon.* |
| 1899 Apr. 14 | | Capt. Windeyer G. | Lingham, *care of W. Lund, 3 East India Avenue, E.C.* |
| 1877 Jan. 12 | * | Louis Stromeyer | Little, B.A. M.D., *Ashdown, Bletchingley, Surrey;* and *Reform Club, Pall Mall, S.W.* |
| 1897 Dec. 10 | | Wm. Jas. Stewart | Lockyer, M.A. Ph.D., 16 *Penywern Road, Earl's Court, S.W.* |
| 1874 Nov. 14 | * | Sir Edmund Giles | Loder, Bart., M.A., *Leonardslee, Horsham, Sussex.* |
| 1886 Jan. 8 | * | Jacob Gerhard | Lohse, *Fünfhausen, bei Elsfleth, Germany.* |
| 1897 June 11 | * | Henry C. | Lord, Director of the Emerson McMillin Observatory and Assistant Professor of Astronomy, *Ohio State University, Columbus, Ohio, U.S.A.* |
| 1897 Feb. 12 | | Ernest F. J. | Love, M.A. Assistant Lecturer and Demonstrator in Natural Philosophy in the University, 213 *Royal Parade, Melbourne, Victoria, Australia.* |

| Date of Election. | | |
|---|---|---|
| 1876 June 9 | * James | Love, 33 *Clanricarde Gardens, Bayswater, W.* |
| 1889 Feb. 8 | * Arthur C. W. | Lowe, B.A., *Gosfield Hall, Halstead, Essex.* |
| 1872 Feb. 9 | * D. Lindsay | Lowson. (*No address: see slip.*) |
| 1897 Jan. 8 | George Edward | Lumsden, Assistant Secretary of the Province of Ontario, 57 *Elm Avenue, Toronto, Canada.* |
| 1862 Feb. 14 | * William Thynne | Lynn, B.A., 26 *South Vale, Blackheath, S.E.* |
| 1880 June 11 | Major F. Denis F. | MacCarthy, R.E., *South Road, Curragh Camp, Co. Kildare, Ireland.* |
| 1896 Jan. 10 | Fredk. William | McCarthy, 11 *Colet Gardens, West Kensington, W.* |
| 1882 Nov. 10 | Jonadab | McCarthy, 11 *Colet Gardens, West Kensington, W.* |
| 1877 Mar. 9 | Frank | McClean, M.A. LL.D. F.R.S., *Rusthall House, Tunbridge Wells*; and 1 *Onslow Gardens, South Kensington, S.W.* |
| 1886 May 14 | John David | McClure, M.A. LL.D., *Mill Hill School, N.W.* |
| 1894 Jan. 12 | Henry | MacEwen, 5 *Cathkin Terrace, Mount Florida, Glasgow, Scotland.* |
| 1892 May 13 | William Grant | MacGregor, F.R.G.S., 18 *Coleman Street, E.C.* |
| 1887 Jan. 14 | Capt. Thomas | Mackenzie, 48 *Fenchurch Street, E.C.* |
| 1885 Apr. 10 | * James | McKerrow, Surveyor-General of New Zealand *Wellington, New Zealand.* |
| 1884 Dec. 12 | * The Hon. Lord | McLaren, LL.D., 46 *Moray Place, Edinburgh.* |
| 1897 Jan. 8 | Major Percy Alexr. | MacMahon, R.A. D.Sc., F.R.S., *Artillery College, Woolwich*; and 52 *Shaftesbury Avenue, W.* |
| 1879 Mar. 14 | Col. Ernest E. | Markwick, *Army Ordnance Department, H.M. Gun Wharf, Devonport.* |
| 1875 Jan. 8 | Charles H. | Marten, *Conduit Lodge, Blackheath Park, S.E.* |
| 1854 Feb. 10 | * Arthur B. | Martin, *Nautical Academy*, 156 *Minories, E.C.* |
| 1898 Jan. 14 | J. Nevil | Maskelyne, 88 *Trinity Road, Upper Tooting, S.W.* |
| 1893 Mar. 10 | Henry Bateman | Massey, *Spalding, Lincolnshire.* |
| 1898 June 10 | * Peter | Matthews, *care of Zach. Cartright, Ltd.*, 10 *Fenchurch Street, E.C.* |
| 1875 Feb. 12 | Edward Walter | Maunder, *Royal Observatory, Greenwich, S.E.* and 86 *Tyrwhitt Road, St. John's, S.E.* |
| 1888 Dec. 14 | WILLIAM HENRY | MAW, TREASURER, 18 *Addison Road, Kensington, W.* |
| 1895 May 10 | * John Willoughby | Meares, Electrical Engineer to Government of Bengal, *Writers' Buildings, Calcutta, India* |
| 1889 Feb. 8 | Arthur B. P. | Mee, 4 *Park Terrace, Penhill, Cardiff, South Wales.* |
| 1877 Mar. 9 | * Raphael | Meldola, F.R.S. F.C.S. F.I.C., Professor of Chemistry in the Finsbury Technical College, City and Guilds of London Institute, 6 *Brunswick Square, W.C.* |

| Date of Election. | | | |
|---|---|---|---|
| 1870 Mar. 11 | | Charles | Meldrum, C.M.G. M.A. LL.D. F.R.S., *care of* W. P. Meldrum, *University Hall, Riddle's Court, Edinburgh.* |
| 1859 Mar. 11 | * | John James | Mellor, M.P., *The Woodlands, Whitefield, near Manchester.* |
| 1883 June 8 | * | Thomas Kilner | Mellor, *Vernon Avenue, Huddersfield.* |
| 1896 Jan. 10 | | Charles J. | Merfield, *Railway Construction, Public Works, Sydney, New South Wales, Australia.* |
| 1886 Feb. 12 | | Duncan | Milligan, 21 *Spencer Rd., New Wandsworth, S.W.* |
| 1891 Jan. 9 | * | John | Mitchell, Jun., *Brockholes, Huddersfield.* |
| 1890 Dec. 12 | * | Rev. John Cairns | Mitchell, M.A. B.D., *Bankura, Bengal, India.* |
| 1881 Mar. 11 | | James Henry | Mitchiner, *The Acacias, Barham Road, South Croydon.* |
| 1892 Feb. 12 | | Arthur Hilton W. | Molesworth, B.A., 15 *Park Lane, W.* |
| 1898 June 10 | * | Capt. Percy B. | Molesworth, R.E., *Trincomali, Ceylon.* |
| 1886 Apr. 9 | | Wm. Hy. Stanley | Monck, M.A., 16 *Earlsfort Terrace, Dublin.* |
| 1879 Jan. 10 | | Rev. J. Holdsworth | Morgan, *Hillside, Woburn Sands, R.S.O., Bucks.* |
| 1886 Feb. 12 | | Colonel W. G. | Morris, R.E., C.R.E., South Africa, *Cape Town.* |
| 1900 June 8 | | Forest Ray | Moulton, Ph.D., Instructor in Astronomy at the University, *Chicago, U.S.A.* |
| 1874 Dec. 11 | | John Fletcher | Moulton, M.A. Q.C. F.R.S., 57 *Onslow Square, South Kensington, S.W.* |
| 1885 Jan. 9 | * | Asutosh | Mukhopadhyay, M.A. LL.D. F.R.S.E., Professor of Mathematics at the Indian Association for the Cultivation of Science, 77 *Russa Road North, Bhowanipur, Calcutta, India.* |
| 1863 Jan. 9 | * | Richard | Munday, *Calverley, Plymouth.* |
| 1885 Jan. 9 | | Kavasjee D. | Naegamvala, M.A., *The Maharajah Takhtasingji Observatory, Poona, India.* |
| 1889 Jan. 11 | * | Frederick Wm. | Nash, *The Firs, Bentley Heath, Knowle, Warwickshire.* |
| 1875 Dec. 10 | | Commr. Chas. B. | Neate, R.N., *Sibertswold, Dover.* |
| 1888 May 11 | | Reginald Carter | Nelson, 19 *Roker Terrace, Sunderland.* |
| 1873 Feb. 14 | | Edmund Neville | Nevill, Government Astronomer, *Observatory, Durban, Natal.* |
| 1891 June 12 | * | HUGH FRANK | NEWALL, M.A., SECRETARY, *Madingley Rise, Cambridge.* |
| 1888 Apr. 13 | * | George James | Newbegin, *Thorpe St. Andrew, Norwich.* |
| 1875 Dec. 10 | * | Francis Murray | Newton, *Barton Grange, Taunton.* |
| 1877 Apr. 13 | * | Frederic | Newton, 3 *Fleet Street, E.C.* |
| 1887 May 13 | * | Gustavus William | Nicolls, *Banco de Pernambuco, Pernambuco, Brazil.* |
| 1854 June 9 | | Sir Andrew | Noble, K.C.B. F.R.S. F.C.S., *Jesmond Dene House, Newcastle-on-Tyne.* |



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|---|---|---|
| 1886 Jan. 8 | * | William Irvin |
| 1895 June 14 | * | Rev. Jas. Dun |
| 1868 Feb. 14 | * | John |
| 1900 Jan. 12 | | Howard |
| 1899 June 9 | | Frederick Eva |
| 1877 Jan. 12 | * | Robert |
| 1900 June 8 | | Wm. Harrison |
| 1885 Mar. 13 | | William |
| 1884 Jan. 11 | * | Sir Cuthbert E. |
| 1879 Jan. 10 | | Charles |
| 1867 Feb. 8 | | Francis Cranm |
| 1885 June 12 | | Rev. Thomas |
| 1895 Feb. 8 | * | Chas. Wm. Dys |
| 1889 May 10 | | James George |
| 1882 Apr. 14 | | Robert Thomas |
| 1870 Jan. 14 | * | J. E. Hunter |
| 1899 May 12 | | Rev. Theodore E |
| 1891 Jan. 9 | | William M. |

| Date of Election. | | | |
|---|---|---|---|
| 1899 Dec. 8 | | Henry C. | Plummer, B.A., *The Owens College, Manchester.* |
| 1879 May 9 | | William Edward | Plummer, M.A., *Liverpool Observatory, Bidston, Birkenhead.* |
| 1893 Nov. 10 | | Charles Lane | Poor, Ph.D., *Johns Hopkins University;* and 4 *East 48th Street, New York City, U.S.A.* |
| 1885 Jan. 9 | * | Rev. T. Cunningham | Porter, B.A., *Eton College, Windsor.* |
| 1895 Feb. 8 | | Charles A. | Post, 16 & 18 *Exchange Place, New York City;* and *Strandhome, Bayport, Suffolk County, N.Y., U.S.A.* |
| 1894 Mar. 9 | | Walter A. | Post, *Newport News, Warwick County, Virginia, U.S.A.* |
| 1854 Jan. 13 | * | Eyre Burton | Powell, C.S.I. M.A., 25 *Kirkstall Road, Streatham Hill, S.W.* |
| 1896 Jan. 10 | | Hugh Griffith | Quirk, *Bay Mount, Vico Road, Dalkey, Co. Dublin, Ireland.* |
| 1893 June 9 | * | Arthur A. | Rambaut, M.A., D.Sc. F.R.S., Radcliffe Observer, *Radcliffe Observatory, Oxford.* |
| 1879 Jan. 10 | | Capt. James | Rankin, *Local Marine Board, Dock Street, E.* |
| 1883 Nov. 9 | | Robert | Rawson, Assoc. Inst.N.A., *Warblington Villa, Havant, Hants.* |
| 1866 Jan. 12 | * | Lord | Rayleigh, M.A. Sc.D. LL.D. D.C.L. F.R.S., *Terling Place, Witham, Essex.* |
| 1893 Dec. 8 | | Chas. Herbt. Edm. | Rea, A.I.A. F.S.S., 223 *Norwood Road, Herne Hill, S.E.* |
| 1888 Apr. 13 | * | Capt. Geo. Wm. | Read, F.R.G.S., *Penworris, Cathedral Road, Cardiff, South Wales.* |
| 1881 Jan. 14 | | Rev. Joseph | Reed, M.A. J.P., *The Rectory, Bellingham, Northumberland.* |
| 1892 Apr. 8 | | John Krom | Rees, A.M. E.M. Ph.D. Director of the Observatory, and Professor of Astronomy, *Columbia University, New York City, U.S.A.* |
| 1896 April 10 | | Edward Ayearst | Reeves, *Royal Geographical Society,* 1 *Savile Row, W.* |
| 1896 Feb. 14 | | Robert Fermor | Rendell, B.A., *The Glen, Blackheath Hill, S.E.* |
| 1899 Feb. 10 | | John H. | Reynolds, 35 *Trinity Road, Birchfield, Birmingham.* |
| 1898 June 10 | | William John | Reynolds, 61 *Fairholt Road, Stamford Hill, N.* |
| 1894 Jan. 12 | | Rev. David Powell | Richards, B.A., *H.M.S. 'Jupiter,' Channel Squadron.* |
| 1876 Feb. 11 | * | Rev. Walter J. B. | Richards, D.D., *St. Charles' College, Ladbroke Grove Road, Notting Hill, W.* |
| 1880 Jan. 9 | * | Arthur | Riches, *Corolanty, East Cliff, Bournemouth.* |
| 1870 Apr. 8 | | Edward Henry | Riches, LL.D., *Agra Lodge, South Cliff, Scarborough.* |





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|---|---|
| N. Rickmer | Rickmers, 23 *Savile Row, W.* |
| Emanuel | Ristori, Assoc.M.Inst.C.E., 2 *Halkin Street, S.W.*; and 9 *Victoria Street, Westminster, S.W.* |
| William | Ritchie, *City Observatory, Calton Hill, Edinburgh.* |
| Frank | Robbins, *City Gas Testing Station*, 10 *Kinghorn Street, Clothfair, E.C.* |
| Alex. William | Roberts, D.Sc. F.R.S.E., *Lovedale, Cape Colony.* |
| Edward | Roberts, F.S.S., *Park Lodge, Eltham, S.E.* |
| Isaac | Roberts, D.Sc. F.R.S., *Starfield, Crowborough, Sussex.* |
| Edward | Robinson, 133 *Castelnau Gardens, Barnes, S.W.* |
| William Henry | Robinson, *Offendene, Walsall, Staffordshire.* |
| Rev.W.Jas.Boden | Roome, 25 *Windsor Road, Ealing, W.* |
| Rev. Thomas | Roseby, M.A. LL.D., *The Parsonage, Marrickville, New South Wales, Australia.* |
| Earl of | Rosse, K.P. B.A. LL.D. D.C.L. F.R.S., *Birr Castle, Parsonstown, Ireland;* and *Athenæum Club, Pall Mall, S.W.* |
| Edward John | Routh, M.A. Sc.D. LL.D. F.R.S., Fellow of the University of London, *Newnham Cottage, Queen's Road, Cambridge.* |
| Chas. Almeric | Rumsey, B.A., *Dulwich College;* and 27 *Park Road, West Dulwich, S.E.* |
| Ly.Chamberlaine | Russell, C.M.G. B.A. F.R.S., Government Astro- |

| Date of Election. | | |
|---|---|---|
| 1891 Jan. 9 | | James Lidderdale Scott, *care of Scott, Harding, & Co., P.O. Box 120, Shanghai, China.* |
| 1870 Apr. 8 | | George Mitchell Seabroke, Temple Observer, *Rosemont, Rugby.* |
| 1893 Nov. 10 | * | Thos. Jefferson J. See, Ph.D., Professor of Mathematics in the U.S. Naval Observatory, *Georgetown Heights Washington, D.C., U.S.A.* |
| 1891 Jan. 9 | * | Arthur Laidlaw Selby, M.A., *University College of South Wales and Monmouthshire, Cardiff, South Wales.* |
| 1897 Jan. 8 | | Beauchamp Prideaux Selby, J.P., *Pawston, Cornhill-on-Tweed, Northumberland.* |
| 1894 Jan. 12 | | Richard Pickering Sellors, B.A., *Government Observatory, Sydney, New South Wales, Australia.* |
| 1884 Dec. 12 | | Harold Seward, B.A., *Patent Office, Southampton Buildings, Chancery Lane, W.C.* |
| 1861 Jan. 11 | | Philip E. Sewell, *Gurney's Bank, Norwich.* |
| 1899 Mar. 10 | | Col. Thos. Davies Sewell, 29 *Grosvenor Road, S.W.* |
| 1893 Dec. 8 | * | William Shackleton, *Royal College of Science, South Kensington, S.W.* |
| 1892 June 10 | * | Martin Charles Sharp, M.A., *Cintra, Hampstead Lane, Highgate, N.* |
| 1890 June 13 | | Thomas Steele Sheldon, M.B.Lond., *Parkside, Macclesfield.* |
| 1878 Apr. 12 | * | Rev. Alfred J. P. Shepherd, B.A., *The Rectory, Sulhampstead, Reading.* |
| 1891 Jan. 9 | * | Rev. Walter Sidgreaves, S.J., *Stonyhurst College Observatory, Blackburn, Lancashire.* |
| 1857 Mar. 13 | * | James Simms, 138 *Fleet Street, E.C.* |
| 1851 Jan. 10 | * | William Simms, *Albert Lodge, Hope Road, Shanklin, Isle of Wight.* |
| 1890 Apr. 11 | | Andrew Simons, F.G.S. F.R.G.S., 21 *Portland Street, Exeter.* |
| 1894 June 8 | | David Goudie Simpson, 199 *Camberwell Grove, Denmark Hill, S.E.* |
| 1892 Jan. 8 | | John Samuel Slater, Professor of Civil Engineering, Civil Engineering Coll., *Seebpore, Calcutta, India.* |
| 1897 Apr. 9 | | John Sisson Slater, M.A. LL.D., 1 *Garden Court, Temple, E.C.;* and *Seafield, Lytham, Lancashire.* |
| 1878 Jan. 11 | * | Rev. Philip R. Sleeman, 65 *Pembroke Road, Clifton, Bristol.* |
| 1889 Dec. 13 | * | David Smart, M.R.C.S. L.R.C.P. L.S.A., 108 *Grange Road, Bermondsey, S.E.* |
| 1861 Mar. 8 | | Rev. Maurice A. Smelt, M.A., *Heath Lodge, Cheltenham.* |
| 1861 May 10 | | Basil Woodd Smith, J.P., *Branch Hill Lodge, Hampstead Heath, N.W.* |
| 1884 May 9 | * | Charles Michie Smith, B.Sc. F.R.S.E., Government Astronomer, *Observatory, Kodaikánal, Palani Hills, South India.* |





ev. E. Harrison Smith, M.A. R.N., *H.M.S. 'Centurion,' China Station.*

eorge Albert Smith, *St. Ann's Gardens, Brighton.*

eo. Fredk. Herbt. Smith, B.A., *British Museum of Natural History, Cromwell Road, S.W.*

ohn Bagnold Smith, *Newstead Colliery, near Nottingham.*

ohn Peter Geo. Smith, *Sweyney Cliff, Coalport, R.S.O., Shropshire.*

ev. William Smith, *Acacia Villa, St. Helen's Road, Hastings.*

'illiam Arthur Smith, 78 *Hagley Road, Edgbaston;* and 94 *Charlotte Street, Birmingham.*

lfred Thos. Odell Sorrell, 39 *Allison Road, Harringay, N.*

'illiam Edward Sparkes, 4 *Roker Terrace, Sunderland.*

ev. Danl. Higham Sparling, B.A., *Christchurch Rectory, Biddulph Moor, near Congleton, Cheshire.*

ev. John Spence, 31 *Beaufort Street, Cheyne Walk, Chelsea, S.W.*

dmund Johnson Spitta, L.R.C.P. Lond., *Ivy House, Clapham Common, S.W.*

. W. Spencer Stanhope, *Cannon Hall, Barnsley, Yorkshire.*

'illiam Ford Stanley, F.G.S. F.R.Met.Soc., *Cumberlow, South Norwood, S.E.*

aptain John Steele, *The Rectory, Flordon, near Norwich.*

harles Stevens, 10 *Wemyss Road, Blackheath, S.E.*

rederick Haller Stevens, B.A., *Clifton College, Bristol.*

apt. Geo. Richd. Stevens, *Hong Kong, China.*

| Date of Election. | | | |
|---|---|---|---|
| 1890 Jan. 10 | * | Hy. Wm. Lloyd | Tanner, M.A. F.R.S., Professor of Mathematics in the University College of South Wales and Monmouthshire, 27 *Cwrt-y-Fil Road, Penarth, South Wales.* |
| 1890 Jan. 10 | | Robt. Lethbridge | Tapscott, Assoc.M.Inst.C.E. F.G.S. F.R.Met. Soc., 62 *Croxteth Road, Liverpool.* |
| 1889 Feb. 8 | | Kenneth James | Tarrant, *Craven Cottage, Bushey Heath, Herts;* and 63 *Threadneedle Street, E.C.* |
| 1892 Nov. 11 | * | John | Tatlock, Jun., M.A., *P.O. Box* 194, *New York City, U.S.A.* |
| 1888 Dec. 14 | | Albert | Taylor, *Gorphwysfa, Cwrt-y-Fil Road, Penarth, South Wales.* |
| 1898 Mar. 11 | | Alfred | Taylor, *c/o T. Cooke & Sons, Buckingham Works, York;* and *Polvellan, Holgate Hill, York.* |
| 1894 Dec. 14 | | Basil R. H. | Taylor, Assistant Harbour Master, *Hong Kong, China.* |
| 1896 Feb. 14 | | Charles Albert | Taylor, 16 *Albert Mansions, Albert Bridge Road, S.W.* |
| 1885 May 8 | * | C. H. Brewitt | Taylor, *care of I.M. Customs, Shanghai, China.* |
| 1899 Dec. 8 | | Clement Jennings | Taylor, *Derby Villa, Derby Road, Kenilworth, Cape Town, S. Africa.* |
| 1886 Feb. 12 | | Rev. Chas. J. | Taylor, M.A. F.C.S., *The Larches, Banstead, Surrey.* |
| 1875 May 14 | * | Henry Martyn | Taylor, M.A., *Trinity College, Cambridge.* |
| 1886 Dec. 10 | | Washington | Teasdale, F.R.M.S., *Headingley, Leeds.* |
| 1873 Jan. 10 | | John | Tebbutt, *Observatory, Windsor, New South Wales.* |
| 1896 Apr. 10 | | Theodore Martin | Teed, C.E. F.R.G.S., 188 *Camberwell Grove, Denmark Hill, S.E.* |
| 1855 June 8 | * | Lt.-Gen. Jas. F. | Tennant, C.I.E. R.E. F.R.S., PAST PRESIDENT, 11 *Clifton Gardens, Maida Hill, W.* |
| 1874 Nov. 13 | * | Dr. François | Terby, 96 *rue des Bogards, Louvain, Belgium.* |
| 1881 Mar. 11 | * | Rev. Thomas R. | Terry, M.A., *The Rectory, East Ilsley, near Newbury, Berks.* |
| 1890 Jan. 10 | | Wm. Grasett | Thackeray, *Royal Observatory, Greenwich;* and 32 *Kidbrooke Park Road, Blackheath, S.E.* |
| 1888 May 11 | | Sir Henry | Thompson, Bart., F.R.C.S. M.B.Lond., 35 *Wimpole Street, W.* |
| 1880 June 11 | * | Capt. Peter | Thompson, *Bolton House, Peak Hill, Sydenham.* |
| 1875 May 14 | | Silvanus Phillips | Thompson, B.A. D.Sc. F.R.S., Principal and Professor of Physics in the City and Guilds of London Technical College, Finsbury, *Morland, Chislett Road, West Hampstead, N.W.* |
| 1885 Jan. 9 | * | Capt. Benjamin | Thomson, Lieut. R.N.R., *The Sycamores, High Bickington, Chulmleigh, N. Devon.* |
| 1875 Feb. 12 | | Wm. Henry | Thornthwaite, *St. Mildred's House, E.C.* |

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|---|---|
| thur | Thornton, M.A., *The Grammar School, Bridlington.* |
| ristopher | Thwaites, M.I.C.E., *Burnell Rd., Sutton, Surrey.* |
| illiam Harold | Tingey, B.A. F.R.Met.Soc., *Rede Court, Rochester, Kent.* |
| : Charles | Todd, K.C.M.G. M.A. F.R.S., Government Astronomer, *Observatory, Adelaide, South Australia.* |
| ptain Henry | Toynbee, 12 *Upper Westbourne Terrace, W.* |
| lien | Tripplin, 31 *Holborn Viaduct, E.C.;* and 23 *Heathfield Gardens, Chiswick, W.* |
| hn Burt | Trivett, Assistant Government Statistician and Actuary to the Public Service Board, *Government Statistician's Office, Sydney, N.S.W., Australia.* |
| swald Thomas | Tuck, *H.M.S.* '*Repulse,*' *Channel Squadron.* |
| ieut.-Col. G. L. | Tupman, R.M.A., *Hillfoot Observatory, College Road, Harrow.* |
| ERBERT HALL | TURNER, M.A. B.Sc. F.R.S., Savilian Professor of Astronomy, Oxford, VICE-PRESIDENT, *University Observatory, Oxford.* |
| dward | Tyer, *Ashwin Street, Dalston, E.* |
| Vm. John Vernon | Vandenbergh, F.R.Met.Soc., *care of W. J. Vandenbergh, 39 Allen Road, South Hornsey, N.* |
| rederick Henry | Varley, 82 *Newington Green Road, Highbury, N.* |

| Date of Election. | | |
|---|---|---|
| 1876 Jan. 14 | * Major-Gen. W. H. | Wardell, R.A., *Beechwood, Winchester.* |
| 1899 Jan. 13 | * Worcester R. | Warner, *Cleveland, Ohio, U.S.A.* |
| 1887 June 10 | * Hy. Addenbrook | Wassell, *Addenbrook Villa, Love Lane, Stourbridge.* |
| 1876 Dec. 8 | * Col. James | Waterhouse, Bengal Staff Corps, *Oak Lodge, Eltham, Kent.* |
| 1884 Feb. 8 | * Frederick William | Watkin, B.A., *St. Paul's School;* and *Colet House, Talgarth Road, West Kensington, W.* |
| 1870 Mar. 11 | * Rev. Hy. Charles | Watson, M.A., *Clifton College, Bristol.* |
| 1885 Apr. 10 | * Lt.-Col. Harry J. | Watson, *The Ridges, Farnborough, Hants.* |
| 1897 Jan. 8 | John | Watson, *Hollymount, Wilpshire, Blackburn, Lancashire.* |
| 1892 Jan. 8 | Wm. Livingstone | Watson, *Ayton, Abernethy, Perthshire;* and 105 *Pall Mall, S.W.* |
| 1878 Jan. 11 | Rev. G. E. | Watts, *Kensworth Vicarage, Dunstable, Herts.* |
| 1888 Feb. 10 | Rev. W. R. | Waugh, *The Observatory, Portland, Dorset.* |
| 1879 Nov. 14 | * Robert Rumsey | Webb, M.A., *St. John's College, Cambridge.* |
| 1875 June 11 | Francis Richard | Wegg-Prosser, M.A., *Merry Hill, Belmont, Hereford.* |
| 1899 Feb. 10 | Thomas | Weir, 56 *Parkfield Street, Moss Lane East, Manchester.* |
| 1897 Feb. 12 | Edward | Weldon, *Didmarton, Frant Rd., Tunbridge Wells.* |
| 1877 Jan. 12 | * Rear-Adm. Sir W. J. L. | Wharton, K.C.B. F.R.S. F.R.G.S., Hydrographer for the Admiralty, *Florys, Prince's Road, Wimbledon Park;* and *Athenæum Club, Pall Mall, S.W.* |
| 1869 Jan. 8 | * Edward John | White, *Observatory, Melbourne, Victoria.* |
| 1893 Mar. 10 | * Edward Turner | Whitelow, 70 *Deansgate, Manchester.* |
| 1898 Dec. 9 | Charles Thomas | Whitmell, M.A. B.Sc., *Invermay, Hyde Park, Leeds.* |
| 1898 Feb. 11 | * Edmund Taylor | Whittaker, M.A., *Trinity College, Cambridge.* |
| 1898 Feb. 11 | Walter | Wickham, *Radcliffe Observatory;* and 62 *St. John's Road, Oxford.* |
| 1895 Jan. 11 | Robert | Wigglesworth, *York;* and 8 *Victoria Street, Westminster, S.W.* |
| 1885 Dec. 11 | Richard | Wilding, *Dalwhinnie, Bromley, Kent.* |
| 1899 Feb. 10 | Algernon Chas. Legge | Wilkinson, B.A., *Trinity College, Cambridge.* |
| 1895 May 10 | William | Willett, Junr., *The Cedars, Chislehurst Common, Kent;* and 2 *Sloane Gardens, S.W.* |
| 1884 May 9 | * Arthur Stanley | Williams, *Bella Vista,* 20 *Hove Park Villas, West Brighton.* |
| 1865 Dec. 8 | * Harry Samuel | Williams, M.A., 6 *Heathfield, Swansea, South Wales.* |
| 1875 Dec. 10 | * William E. | Wilson, F.R.S., *Daramona, Streete, Rathowen, Ireland.* |

| Date of Election. | | |
|---|---|---|
| 1860 Mar. 9 | Rev. Thomas | Wiltshire, M.A. D.Sc. F.G.S. F.L.S., Emerit Professor of Geology and Mineralo King's College, London; 25 *Granvi Park, Lewisham, S.E.* |
| 1898 May 13 | Rev. Wm. Edward | Winks, 58 *Richmond Road, Cardiff, South Wal* |
| 1894 Jan. 12 | Max | Wolf, Ph.D., Professor der Astronomie an d Universität, *Astrophysikalisches Obser torium, Heidelberg, Germany.* |
| 1877 Feb. 9 | * Arthur Mason | Worthington, M.A. F.R.S., *R.N.E. Colle Devonport;* and *Mohuns, Tavistock, Devo* |
| 1879 Jan. 10 | Arthur W. | Wright, Ph.D., Professor of Physics at Y University, *New Haven, Connecticut, U.S.* |
| 1867 Apr. 12 | * Stephen M. | Yeates, 2 *Grafton Street, Dublin.* |
| 1862 Dec. 12 | Sir Allen | Young, C.B., 18 *Grafton Street, Bond Street,* |
| 1896 May 8 | Alfred Ernest | Young, Assoc.M.Inst.C.E., *Trigonometrical S vey of Perak, Taiping, Perak, Straits Set ments.* |
| 1893 May 12 | James Henry | Young, B.Sc., *Office of Works, Storey's Ga Westminster, S.W.* |
| 1877 Jan. 12 | * Jesse | Young, F.R.G.S., *Wisbech, Cambridgeshire.* |
| 1898 Jan. 14 | Thomas Emley | Young, B.A., Pres. Inst. Actuaries, 108 *Evers Road, Stoke Newington, N.* |
| 1875 June 11 | Prof. C. Venceslas | Zenger, *Palais Lobkowitz 7/III. Prag Bohemia.* |

# ASSOCIATES.

| Date of Election. | | |
|---|---|---|
| 1866 May 11 | G. F. J. Arthur | Auwers, Ph.D., Professor, *Lindenstrasse* 91, *Berlin, S.W.* |
| 1898 Dec. 9 | O. | Backlund, Directeur de l'Observatoire Central Nicolas, *Poulkovo, Russia.* |
| 1882 Nov. 10 | H. G. van de Sande | Bakhuyzen, Professor in the University and Director of the Observatory, *Leiden, Holland.* |
| 1898 Dec. 9 | Edward Emerson | Barnard, D.Sc. F.R.A.S., *Yerkes Observatory, Williams Bay, Wisconsin, U.S.A.* |
| 1890 Dec. 12 | Lewis | Boss, Professor, Director of the Dudley Observatory, *Albany, N.Y., U.S.A.* |
| 1884 Nov. 14 | Theodor | Brédikhine, Emeritus Professor, Doctor of Astronomy, *Imperial Academy of Sciences, St. Petersburg, Russia.* |
| 1898 Dec. 9 | Sherburne Wesley | Burnham, M.A. F.R.A.S., Professor of Practical Astronomy in the University of Chicago, *Government Building, Chicago, U.S.A.* |
| 1889 Nov. 8 | Seth C. | Chandler, 16 *Craigie Street, Cambridge, Mass., U.S.A.* |
| 1890 Dec. 12 | Marie Alfred | Cornu, Membre de l'Académie des Sciences et du Bureau des Longitudes, Professeur à l'École Polytechnique, 9 *rue de Grenelle, Paris.* |
| 1898 Dec. 9 | Colonel Gilbert | Defforges, Correspondant du Bureau des Longitudes, *Bureau français restant de Galata, Constantinople.* |
| 1889 Nov. 8 | Nils Christian | Dunér, Ph.D., Professor, Director of the Observatory, *Upsala, Sweden.* |
| 1892 Nov. 11 | W. L. | Elkin, Ph.D., *Yale University Observatory, New Haven, Conn., U.S.A.* |
| 1848 May 12 | Hervé Aug. Ét. Albans | Faye, Membre de l'Institut et Président du Bureau des Longitudes, 95 *Avenue des Champs-Elysées, Paris.* |
| 1866 May 11 | Wilhelm | Förster, Professor, Director der Sternwarte, *Enckeplatz* 3*a*, *Berlin*, S.W. |

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|---|---|
| ann Gottfried | Galle, Ph.D., Professor, *Kiez-Strasse* 17, *Potsdam, Germany.* |
| orge E. | Hale, D.Sc. F.R.A.S., Director of the Yerkes Observatory, *Williams Bay, Wisconsin, U.S.A.* |
| aph | Hall, *Goshen, Connecticut, U.S.A.* |
| edrich Robert | Helmert, Ph.D., ordentliche Professor an der Universität, Berlin; Director des Königl. preussischen Geodätischen Instituts und des Centralbureaus der Internationalen Erdmessung, *Potsdam, Germany.* |
| l P. | Henry, Astronome à l'Observatoire, *Paris.* |
| sper M. | Henry, Astronome à l'Observatoire, *Paris.* |
| orge William | Hill, Ph.D., *West Nyack, N.Y., U.S.A.* |
| ward Singleton | Holden, M.A. Sc.D. LL.D., *The Century Club, 7 West 43rd Street, New York City, U.S.A.* |
| es | Janssen, Membre de l'Institut et du Bureau des Longitudes, Directeur de l'Observatoire d'Astronomie Physique, *Meudon, Seine-et-Oise, France.* |
| obus Cornelius | Kapteyn, Ph.D. Professor of Astronomy at the University, *Groningen, Holland.* |
| nes Edward | Keeler, D.Sc. F.R.A.S., Director of the Lick Observatory, *San José, California, U.S.A.* |

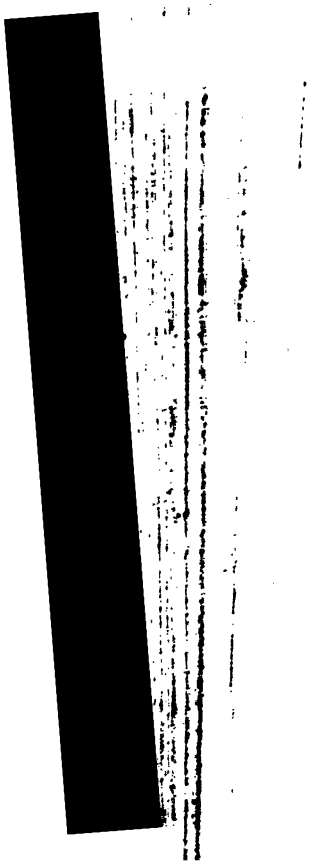
| Date of Election. | | |
|---|---|---|
| 1881 June 10 | Edward Charles | Pickering, D.Sc., Professor, Director of the Observatory, *Harvard College, Cambridge, Mass., U.S.A.* |
| 1894 Nov. 9 | Henri | Poincaré, Membre de l'Institut, Professeur à la Faculté des Sciences, 63 *rue Claude Bernard, Paris.* |
| Dec. 9 | Henry A. | Rowland, Ph.D. LL.D. F.R.S., Professor of Physics and Director of the Physical Laboratory, Johns Hopkins University, 915 *Cathedral Street, Baltimore, Md., U.S.A.* |
| 1866 May 11 | Truman Henry | Safford, B.A. Ph.D., Field Memorial Professor of Astronomy, Williams College, *Williamstown, Mass., U.S.A.* |
| 1872 Nov. 8 | Giovanni Virginio | Schiaparelli, Direttore del R. Osservatorio di Brera, *Milan.* |
| 1898 Dec. 9 | Wilhelm | Schur, Ph.D., Professor der Astronomie, und Director der Königlichen Sternwarte, *Göttingen, Germany.* |
| 1892 Nov. 11 | Hugo | Seeliger, Ph.D., Professor der Astronomie an der Universität, Director der Königlichen Sternwarte, *München, Bavaria.* |
| 1892 Nov. 11 | Hermann | Struve, Ph.D., Director der Universitäts-Sternwarte, *Königsberg, Germany.* |
| 1848 May 12 | Otto | Struve, *Fuhnstrasse* 8, *Karlsruhe, Baden, Germany.* |
| 1883 Nov. 9 | Pietro | Tacchini, Professore, Direttore dell' Ufficio centrale di Meteorologia e Geodynamica, dell' Osservatorio del Collegio Romano ed annesso Museo, *Via del Caravita* 7, *Rome.* |
| 1899 Nov. 10 | Juan M. | Thome, Director, Observatorio Nacional Argentino, *Cordoba, Argentine Republic.* |
| 1882 Nov. 10 | Hermann Carl | Vogel, Ph.D., Professor, Director des Königlichen Astrophysikalischen Observatoriums, *Potsdam, Germany.* |
| 1883 Nov. 9 | Edmund | Weiss, Ph.D., Professor, Director der K.K. Sternwarte, *Wien* (*Währing*), *Austria.* |
| 1874 Jan. 9 | Chas. Joseph Étienne | Wolf, Membre de l'Institut, Astronome de l'Observatoire, Professeur à la Sorbonne, 1 *rue des Feuillantines, Paris.* |
| 1872 Nov. 8 | Charles A. | Young, Professor, College of New Jersey, *Princeton, New Jersey, U.S.A.* |


SPOTTISWOODE

# OYAL ASTRONOMICAL SOCIETY.

## LIST OF FELLOWS AND ASSOCIATES.

JUNE 1902.



Sir WILLIAM ABI
W. H. M. CHRIST.
E. B. KNOBEL, Es
H. F. NEWALL, Es

W. H. MAW, Esq.

F. W
E. T.

Fo
Sir WILLIAM HUGGI

Sir R. S. BALL, M.A.
Astronomy and G
A. A. COMMON, Esq.
A. M. W. DOWNING, E
of the Nautical A
Major E. H. HILLS, R.
THOMAS LEWIS, Esq.
FRANK MCCLEAN, Es
Major P. A. MACMAHO
A. A. RAMBAUT, Esq.
G. M. SEABROKE, Esq
E. J. SPITTA, Esq.
W. G. THACKERAY, Es
H. H. TURNER, Esq. D.
Astronomy, Oxford

# LIST OF THE FELLOWS

OF THE

# ROYAL ASTRONOMICAL SOCIETY,

JUNE 1902.

An asterisk (*) prefixed to a name indicates that the member has compounded for his Annual Contributions.

The present addresses of the following Fellows are not known, and the Secretaries would be glad of any information which would enable them to be traced:

| | LAST KNOWN ADDRESS. |
|---|---|
| John James ... ... | Aubertin, Langton House, Shooter's Hill Road, S.E. (1901 Nov.) |
| *J. Owen Corrie ... ... | 131 Denmark Terrace, Brighton. (1896 June.) |
| *Isaac Engelson ... | Pomme d'Or, Jersey. (1897 Nov.) |

| | | |
|---|---|---|
| 1893 Mar. 10 | | Maur. Anderson Ainslie, R.N. B.A., *H.M.S. 'Britannia,' Dartmouth.* |
| 1896 Jan. 10 | * | Hugh Lancelot Aldis, 10 *Old Grange Road, Durham Road, Sparkhill, Birmingham.* |
| 1885 Mar. 13 | * | Wm. Steadman Aldis, M.A., *Kidlington, near Oxford.* |
| 1902 Jan. 10 | | Ashton Charles Allen, 34 *Kensington Palace Mansions, De Vere Gardens, W.* |
| 1880 Nov. 12 | * | Rev. Francis B. Allison, M.A., *The Vicarage, Peasmarsh, Sussex.* |
| 1867 Nov. 8 | | Thomas Michael Almond, Port Master, *Brisbane, Queensland, Australia.* |
| 1896 Apr. 10 | | William Anderson, *care of W. Anderson, Ballee House, Ballymena, Co. Antrim, Ireland.* |

# LIST OF THE FELLOWS

OF THE

# 'YAL ASTRONOMICAL SOCIETY,

JUNE 1902.

An asterisk (*) prefixed to a name indicates that the member has compounded for his Annual Contributions.

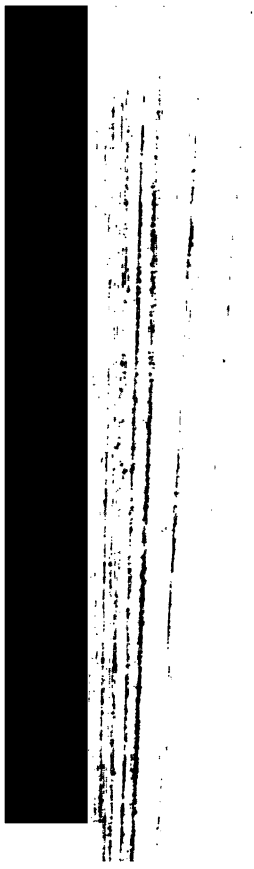
*ould any errors or omissions be found in this List, it is requested that notice thereof be given to the Assistant Secretary.*

PATRON:

HIS MAJESTY THE KING.

## FELLOWS.

| f Election | | | |
|---|---|---|---|
| Jan. 14 | * | Prof. Cleveland Abbe, | *Weather Bureau, Department of Agriculture, Washington, D.C., U.S.A.* |
| Apr. 8 | | Sir Wm. de W. Abney, | K.C.B. R.E. D.C.L. F.R.S., Vice-President, Past President, *Rathmore Lodge, Bolton Gardens South, S.W.* |
| June 13 | | Henry Bridger | Adames, 8 *West Street, Chichester, Sussex.* |
| Mar. 9 | * | Rev. E. Aurelius | Adams, M.A., 10 *Hove Park Villas, Hove, Sussex.* |
| Feb. 10 | | Harold John | Adams, M.A., *St. John's, Oakwood Avenue, Beckenham.* |
| Mar. 10 | | Maur. Anderson | Ainslie, R.N. B.A., *H.M.S. 'Britannia,' Dartmouth.* |
| Jan. 10 | * | Hugh Lancelot | Aldis, 10 *Old Grange Road, Durham Road, Sparkhill, Birmingham.* |
| Mar. 13 | * | Wm. Steadman | Aldis, M.A., *Kidlington, near Oxford.* |
| Jan. 10 | | Ashton Charles | Allen, 34 *Kensington Palace Mansions, De Vere Gardens, W.* |
| Nov. 12 | * | Rev. Francis B. | Allison, M.A., *The Vicarage, Peasmarsh, Sussex.* |
| Nov. 8 | | Thomas Michael | Almond, Port Master, *Brisbane, Queensland, Australia.* |
| Apr. 10 | | William | Anderson, *care of W. Anderson, Ballee House, Ballymena, Co. Antrim, Ireland.* |



| | | |
|---|---|---|
| 1873 Apr. 9 | * Thos. William | |
| 1888 Feb. 10 | Rev. J. Mackenzie | |
| 1892 June 10 | Rev. James | |
| 1900 Nov. 9 | Arthur H. | |
| 1875 Mar. 12 | * Sir Robt. Stawell | J |
| 1898 May 13 | George | B |
| 1896 May 8 | William | B |
| 1884 Nov. 14 | Pietro | B |
| 1899 Nov. 10 | Rev. Thos. Gerrard | Ba |
| 1895 Feb. 8 | Edwin | Ba |
| 1893 Feb. 10 | Samuel | Ba |
| 1874 May 8 | * Rev. H. Glanville | Ba |
| 1888 Jan. 13 | * Edward Emerson | Bar |
| 1901 Jan. 11 | Henry Osmund | Bar |
| 1879 May 9 | Capt. Edward | Barn |
| 1899 Apr. 14 | * Ernest William | Barn |
| 1881 May 13 | * John Alfred | Barri |
| 1880 Apr. 9 | * | |

| Date of Election. | | |
|---|---|---|
| 1892 May 13 | Henry | Baynham, R.N., Captain, *H.M.S.* '*Wellesley*, *Training Ship, North Shields.* |
| 1893 June 9 | Hedley Robert | Beasley, *Hornsey Grammar School, Stapleton Hall Road, N.* |
| 1877 May 11 | * William Morris | Beaufort, F.R.G.S., 18 *Piccadilly, W.*; and *Athenæum Club, S.W.* |
| 1893 Apr. 14 | Ludwig | Becker, Ph.D. F.R.S.E., Professor of Astronomy in the University of Glasgow, *Observatory, Glasgow.* |
| 1862 Apr. 11 | Capt. James F. | Beckett, R.N., *Avondell, Hollington Park, St. Leonards-on-Sea.* |
| 1902 Jan. 10 | John Hind | Bell, 'Nautical Almanac' Office, 3 *Verulam Buildings, Gray's Inn, W.C.* |
| 1896 Feb. 14 | Frank Arthur | Bellamy, F.R.Met.Soc., *University Observatory*; and 4 *St. John's Road, Oxford.* |
| 1892 Feb. 12 | Bertram | Bennett, M.A., *Montpelier, Paignton, South Devon.* |
| 1888 Mar. 9 | * Arthur | Berry, M.A., *King's College, Cambridge.* |
| 1893 Jan. 13 | Joseph Ibbitson | Berry, *Hazeldene, Avenue Road, Highgate, N.* |
| 1866 Nov. 9 | * Rev. Frank | Besant, M.A., *Sibsey Vicarage, Boston, Lincolnshire.* |
| 1854 Feb. 10 | * Wm. Henry | Besant, M.A. Sc.D. F.R.S., *St. John's College, Cambridge.* |
| 1902 Jan. 10 | * Walter Ernest | Besley, 75 *The Chase, Clapham Common, S.W.* |
| 1890 Jan. 10 | Algernon Sidney | Bicknell, *Barcombe House, Barcombe, Sussex.* |
| 1869 Jan. 8 | * Lieut.-Col. A. C. | Bigg-Wither, *Tilthams, Godalming, Surrey.* |
| 1881 Jan. 14 | Raphael Louis | Bischoffsheim, *Observatoire, Nice*; and 3 *rue Taitbout, Paris.* |
| 1875 Apr. 9 | Lord | Blythswood, *Blythswood, near Renfrew, Scotland*; and 2 *Seamore Place, Curzon Street, W.* |
| 1894 Apr. 13 | Lyndon | Bolton, B.A., *Patent Office, Southampton Buildings, Chancery Lane, W.C.* |
| 1894 Dec. 14 | George Cox | Bompas, F.G.S. F.R.G.S., 121 *Westbourne Terrace, W.* |
| 1887 Apr. 6 | Rev. John | Bone, A.K.C., *St. Thomas's Vicarage, Lancaster.* |
| 1902 Jan. 10 | James Henry | Booth, F.R.G.S., *Alton, Stoke-upon-Trent, Staffs.* |
| 1871 Nov. 10 | * Robt. Holford M. | Bosanquet, M.A. F.R.S., *Castillo Zamora, Realejo Alto, Teneriffe, Canary Islands.* |
| 1889 Jan. 11 | * Henry Lord | Boulton, *Carácas, Venezuela, South America.* |
| 1895 Feb. 8 | Vincent Joseph | Bouton, B.Sc., 9 *Lansdowne Terrace, Hampton Wick.* |
| 1892 Dec. 9 | John A. | Brashear, *Allegheny, Pennsylvania, U.S.A.* |
| 1893 Jan. 13 | Martin | Brendel, Ph.D., Professor of Theoretical Astronomy and Geodesy in the University, 12 *Schildweg, Göttingen, Germany.* |

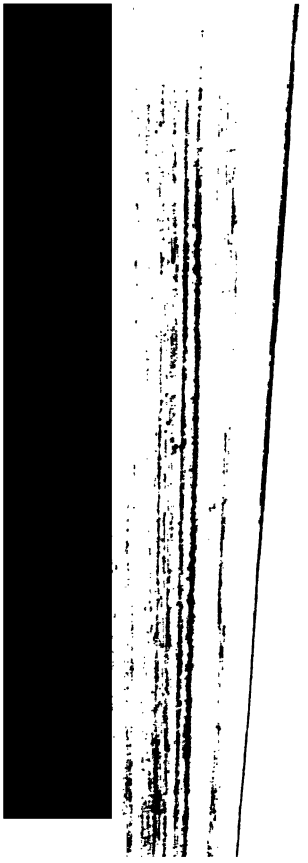
| Date of Election. | | | |
|---|---|---|---|
| 1877 June 8 | * | Thomas Dalby | Brewin, *Burlington House*, 43 *St. Alban's Road, Leicester.* |
| 1894 Jan. 12 | * | William | Briggs, M.A. LL.B. F.C.S., *Burlington House, Cambridge.* |
| 1899 Jan. 13 | * | Charles Lewis | Brook, M.A. F.R.Met.Soc., *Harewood Lodge, Meltham, near Huddersfield, Yorkshire.* |
| 1891 Jan. 9 | * | Joseph | Brooks, F.R.G.S., *Hope Bank, Nelson Street, Woollahra, Sydney, N.S. Wales, Australia.* |
| 1888 Jan. 13 | | William R. | Brooks, M.A. D.Sc., Director of the Smith Observatory, *Box* 714, *Geneva, N.Y., U.S.A.* |
| 1889 Jan. 11 | * | Ernest William | Brown, M.A. Sc.D. F.R.S., Professor of Applied Mathematics, *Haverford College, Pennsylvania, U.S.A.; and Christ's College, Cambridge.* |
| 1888 Feb. 10 | * | John Henry | Brown, 6 *Cambridge Road, Brighton.* |
| 1891 Jan. 9 | * | James Stark | Browne, *The Red House, Mount Avenue, Ealing, W.* |
| 1890 May 9 | | Thomas William | Brownell, 64 *Upper Brook Street, Manchester.* |
| 1865 Mar. 10 | | John | Browning, 63 *Strand, W.C.* |
| 1887 Dec. 9 | | Hon. Justice Gainsford Bruce, K.C., *Yewhurst, Bromley, Kent.* | |
| 1902 Apr. 11 | | George Herbert | Bryant, *Drybrook, Gloucestershire.* |
| 1882 Nov. 10 | * | Robert | Bryant, B.A. D.Sc., *London Institution, Finsbury Circus, E.C.* |
| 1892 Dec. 9 | * | Walter William | Bryant, B.A., *Royal Observatory, Greenwich*; and 179 *Westcombe Hill, Blackheath, S.E.* |
| 1894 Jan. 12 | | John Harrison | Buckley, 70 *Tower Street, Leicester.* |
| 1892 Feb. 12 | | Charles | Burckhalter, *Chabot Observatory*, and 1224 *Linden Street, Oakland, California, U.S.A.* |
| 1897 Apr. 9 | | Rev. Sherrard B. | Burnaby, M.A., *Longfield, Great Missenden, Bucks.* |
| 1874 Nov. 13 | * | Sherburne W. | Burnham, Hon. M.A. of Yale College, Professor of Practical Astronomy in the University of Chicago, *Government Building, Chicago, U.S.A.* |
| 1885 Apr. 10 | * | Major Sidney G. | Burrard, R.E., Superintendent of the Great Trigonometrical Survey of India, *Dehra Dún, N.W.P., India.* |
| 1865 Apr. 12 | * | Col. Alexander | Burton-Brown, R.A. F.G.S., 11 *Union Crescent, Margate.* |
| 1900 Apr. 11 | | Thomas C. | Bush, *Somerville, Wells Road, Bath.* |
| 1871 May 12 | * | Reginald | Bushell, *Hinderton Lodge, Neston, Cheshire.* |
| 1887 Apr. 10 | * | Warren Fredk. | Caborne, C.B. Commander R.N.R. F.R.G.S. F.R.Met.Soc., *Claremont*, 54 *Alexandra Road, Upper Norwood, S.E.* |
| 1877 June 8 | * | George | Calver, *Hill House, Widford, Chelmsford.* |

| Date of Election. | | | |
|---|---|---|---|
| 1901 Jan. 11 | | Archd. Young Gipps | Campbell, I.C.S., *Nandiyal Railway Station P.O., Kurnool District, South India.* |
| 1889 May 10 | * | Edward | Carpmael, B.A. Assoc. Inst. C.E., *The Ivies, St. Julian's Farm Road, West Norwood, S.E.* |
| 1873 Feb. 14 | * | Ernest | Carpmael, M.A. K.C., *Ferndale, Woodside Road, Sutton, Surrey.* |
| 1891 Jan. 9 | | Edward Tremlett | Carter, Assoc. Inst. E.E., *Rose Bank, 40 Alexandra Road, Upper Norwood, S.E.* |
| 1896 Mar. 13 | * | James | Cavan, M.A., *Eaton Mascott Hall, Shrewsbury.* |
| 1901 May 10 | * | Jnan Saran | Chakravarti, M.A., Assistant Accountant-General, *Allahabad, India.* |
| 1879 Nov. 14 | | Rev. James Law | Challis, M.A., *The Vicarage, Stone, Aylesbury.* |
| 1864 Feb. 12 | | George Fredk. | Chambers, *Lethen Grange, Sydenham, S.E.* |
| 1901 Mar. 8 | | Robert William | Chapman, M.A. B.C.E., Lecturer in Engineering and Physical Science, *University, Adelaide, South Australia.* |
| 1895 Jan. 9 | | Lt.Col. W. St. L. | Chase, V.C. F.R.G.S., 7th Bombay Infantry, *Quetta, Beluchistan.* |
| 1899 Apr. 14 | | Samuel | Chatwood, M.Inst.M.E. F.R.G.S., *High Lawn, Broadoak Park, Worsley, Manchester.* |
| 1902 Mar. 14 | | J. W. Lawrence | Child, *Vernham, Merton Hall Road, Wimbledon.* |
| 1871 Mar. 13 | * | W. H. MAHONEY | CHRISTIE, C.B. M.A. D.Sc. F.R.S., Astronomer Royal, VICE-PRESIDENT, PAST PRESIDENT, *Royal Observatory, Greenwich, S.E.* |
| 1891 Dec. 11 | | Lord Edw. Spencer | Churchill, 28 *Grosvenor Street, W.* |
| 1897 Feb. 12 | | John Charles | Clancey, F.R.G.S. F.S.I., Assistant Director of Land Records and Agriculture, *New Public Buildings, Rangoon, Burma.* |
| 1894 June 8 | | Rev. John Thos. W. | Claridge, M.A., 3 *Albert Road, Tamworth, Staffordshire.* |
| 1900 Jan. 12 | | Maurice Harvey | Clarke, Lieut. R.N.R. F.R.G.S., *Coleswood, Harpenden, Herts;* and *Board of Trade Surveyor's Office, 79 Mark Lane, E.C.* |
| 1896 Feb. 14 | | Thomas Folkes | Claxton, Director of the Royal Alfred Observatory, *Mauritius.* |
| 1897 May 14 | | Arthur W. | Clayden, M.A. F.G.S., *St. John's, Polsloe Road, Exeter.* |
| 1860 Apr. 13 | * | Robert Bellamy | Clifton, M.A. F.R.S., Professor of Experimental Philosophy in the University of Oxford, 3 *Bardwell Road, Banbury Road, Oxford.* |
| 1859 Feb. 11 | | John Francis | Cole, *Westfield, Cheam Road, Sutton, Surrey.* |
| 1900 Nov. 9 | | William Henry | Colegrave, R.N.R., *Little Tew, Enstone, Oxford.* |
| 1853 June 10 | | Everard Home | Coleman, 71 *Brecknock Road, Camden Road, N.* |
| 1884 Feb. 8 | * | William | Coleman, *The Shrubbery, Buckland, Dover.* |



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| [illegible] | | [illegible] |
| 1883 June 8 | | Hon. Wm. He: |
| 1902 Jan. 10 | | Arthur Thoma: |
| 1891 June 12 | | Rich. Edw. Syn |
| 1881 Jan. 14 | * | William Ernest |
| 1874 Jan. 9 | * | Ralph |
| 1876 Nov. 12 | * | J. Owen |
| 1891 Jan. 9 | * | Rev. Aloysius |
| 1862 Feb. 14 | | Arthur |
| 1896 Feb. 14 | * | Philip H. |
| 1890 Mar. 14 | | Rev. S. Runsie |
| 1871 Jan. 13 | * | The Earl of |
| 1868 Feb. 14 | | George Stickla |
| 1891 Jan. 9 | * | William Blade |
| 1868 Nov. 13 | * | Edward |
| 1888 Nov. 9 | | Andrew C. de la |
| 1901 June 14 | | [illegible] |

| Date of Election. | | | |
|---|---|---|---|
| 1871 June 9 | * | Rev. Reginald F. | Dale, M.A., 12 *Bradmore Road, Oxford.* |
| 1888 May 11 | * | Thomas R. | Dallmeyer, 25 *Newman Street, Oxford Street, W.* |
| 1898 Dec. 9 | * | Lieut. Tristan | Dannreuther, R.N. F.R.G.S., *Windycroft, Hastings, Sussex.* |
| 1892 June 10 | | John | Dansken, F.S.I., 2 *Hillside Gardens, Partick Hill, Glasgow, Scotland.* |
| 1879 Nov. 14 | * | George Howard | Darwin, M.A. LL.D. F.R.S., Plumian Professor of Astronomy in the University of Cambridge, PAST PRESIDENT, *Newnham Grange, Cambridge.* |
| 1888 Jan. 13 | * | Major Leonard | Darwin, R.E., 12 *Egerton Place, S.W.* |
| 1901 Jan. 11 | * | Charles Rundle | Davidson, *Royal Observatory; and* 41 *Park Street, Greenwich, S.E.* |
| 1889 Mar. 8 | * | Rev. C. D. Percy | Davies, M.A., *East Marden Rectory, Chichester, Sussex.* |
| 1869 Mar. 12 | * | Rev. Robert P. | Davies, M.A., *Hatherop Rectory, Fairford, Gloucestershire.* |
| 1875 May 14 | * | Percy L. H. | Davis, '*Nautical Almanac*' *Office*, 3 *Verulam Buildings, Gray's Inn, W.C.* |
| 1889 Nov. 8 | * | Richard Evan | Day, M.A., *Culver, Plaistow Lane, Bromley, Kent.* |
| 1877 June 8 | | William Fredk. | Denning, 34 *Egerton Road, Bishopston, Bristol.* |
| 1895 Feb. 8 | | Henri | Deslandres, D. ès Sc., *Observatoire, Meudon,* and 56 *bis, Route des Gardes, Bellevue, Seine-et-Oise, France.* |
| 1899 Feb. 10 | | William Lee | Dickinson, M.D. F.R.C.P., 9 *Chesterfield Street, Mayfair, W.* |
| 1897 Feb. 12 | * | William Fraser | Doak, M.A., '*Nautical Almanac*' *Office*, 3 *Verulam Buildings, Gray's Inn, W.C.* |
| 1893 Nov. 10 | | William Murray | Dobie, M.D. J.P., *Kirkton House, Chester.* |
| 1898 Nov. 11 | | Cecil G. J. | Dolmage, M.A. LL.D. D.C.L., 22 *Upper Merrion Street, Dublin.* |
| 1898 Mar. 11 | | Eric | Doolittle, B.Sc, *Flower Observatory, University of Pennsylvania, Philadelphia, Pa., U.S.A.* |
| 1898 Nov. 11 | | Andrew Ellicott | Douglass, B.A., *Lowell Observatory, Flagstaff, Arizona, U.S.A.* |
| 1875 Mar. 12 | | Arthur M. W. | Downing, M.A. D.Sc. F.R.S., Superintendent of the 'Nautical Almanac,' 3 *Verulam Buildings, Gray's Inn, W.C.;* and 3 *Grantville Park, Blackheath, S.E.* |
| 1893 Feb. 10 | | Patrick | Doyle, F.R.S.E. M.R.I.A., 19 *Lall Bazar Street, Calcutta, India.* |
| 1875 Mar. 12 | | John L. E. | Dreyer, Ph.D., *Observatory, Armagh, Ireland.* |
| 1888 Apr. 13 | | John Edmund | Drower, *Warwick House,* 15 *Mount Ephraim Road, Streatham, S.W.* |



| | |
|---|---|
| 1880 May 14 | Major Lindsay |
| 1894 May 11 | Rev. Fras. Joh |
| 1859 July 8 | Robt. Lewis Jo |
| 1893 June 9 | Edwin Bailey |
| 1898 June 10 | * Henry |
| 1864 Dec. 9 | * William |
| 1872 Feb. 9 | * Isaac |
| 1872 Feb. 9 | * J. Kennedy |
| 1878 Jan. 11 | Rev. T. H. E. C. |
| 1898 May 13 | Edward Iszatt |
| 1863 Feb. 13 | * William |
| 1895 Feb. 8 | Chas. Roberts D' |
| 1858 Mar. 12 | * Rev. Charles |
| 1882 June 9 | Franklen George I |
| 1886 Jan. 8 | Joseph Edward E |
| 1896 Nov. 13 | Lewis E |
| 1894 Jan. 12 | * John E |

| Date of Election. | | | |
|---|---|---|---|
| 1858 Dec. 10 | | Rev. Adam Storey | Farrar, D.D., *The College, Durham.* |
| 1889 Jan. 11 | * | Samuel | Fellows, *Tynwald Villas, Lower Villier Street, Wolverhampton.* |
| 895 June 14 | * | John A. | Ferguson, 1 and 2 *Ferguson Building, Denver, Colorado, U.S.A.* |
| 1887 June 10 | | Capt. A. Mostyn | Field, R.N., *Bronterille, Merton Road, Southsea.* |
| 1900 June 8 | | Louis Napoleon Geo. | Filon, M.A., Fellow of and Assistant Professor of Applied Mathematics at University College, London, *King's College, Cambridge,* and *Godwin House, St. Augustine's Road, South Croydon.* |
| 1893 Mar. 9 | * | Gerard Brown | Finch, M.A., 1 *St. Peter's Terrace, Cambridge.* |
| 1873 Nov. 14 | * | Wm. Henry | Finlay, M.A., *Dalrymple House, Rickmansworth, Herts.* |
| 1864 May 13 | | Henry Philip | Finlayson, *Avenue Villas, Frith Road, Dover.* |
| 1890 Nov. 14 | * | Hon. Justice Robert Isaac | Finnemore, J.P. F.R.Hist.S., *Supreme Court, Pietermaritzburg, Natal.* |
| 1891 May 8 | | Alfred Henry | Fison, D.Sc. *University College, Gower Street, W.C.;* and 25 *Blenheim Gardens, Willesden Green, N.W.* |
| 1901 Jan. 11 | | Ambrose T. | Flagg, M.A., *Chapel House, Westoe, South Shields.* |
| 1878 Apr. 12 | | Camille | Flammarion, *rue Cassini* 16, *Avenue de l'Observatoire, Paris;* and *Observatoire de Juvisy, Seine-et-Oise, France.* |
| 1878 Jan. 11 | | Rev. David | Fleming, *Vicarage, Coxhoe, R.S.O., Co. Durham.* |
| 1901 Nov. 8 | | Spencer L. | Fletcher, 38 *Lammas Park Road, Ealing, W.* |
| 1900 May 11 | * | Alexander | Foote, J.P. F.S.A.Scot., *The Rectory, Melcombe, Bingham, Dorchester, Dorset;* and *Mall Park, Montrose, Scotland.* |
| 1884 Apr. 9 | | Capt. Duncan | Forbes, *Nautical Academy,* 169 *High Street, Southampton.* |
| 1873 Jan. 10 | * | George | Forbes, M.A. F.R.S. M.Inst.C.E. M.Inst.E.E., 34 *Great George Street, Westminster, S.W.* |
| 1898 May 13 | * | Hon. Geo. Stuart | Forbes, H.M. India Civil Service, *Ootacamund, Madras Presidency, India.* |
| 1893 Mar. 10 | | James Arthur | Formoy, F.C.S., *Chestham, Grange Road, Sutton, Surrey.* |
| 1895 May 10 | * | Andrew Russell | Forsyth, M.A. Sc.D. LL.D. F.R.S., Sadlerian Professor of Pure Mathematics, *Trinity College, Cambridge.* |
| 1895 Dec. 13 | | Major Kingsley O. | Foster, J.P., *Shenley, Redhill, Surrey.* |
| 1889 Dec. 13 | * | Alfred | Fowler, Assistant Professor of Physics, *Royal College of Science, South Kensington;* and 7 *Cortayne Road, Fulham, S.W.* |
| 1896 Jan. 10 | | Alpin G. | Fowler, M.Inst.C.E., 1 *Cambridge Road, Norbiton, Surrey.* |



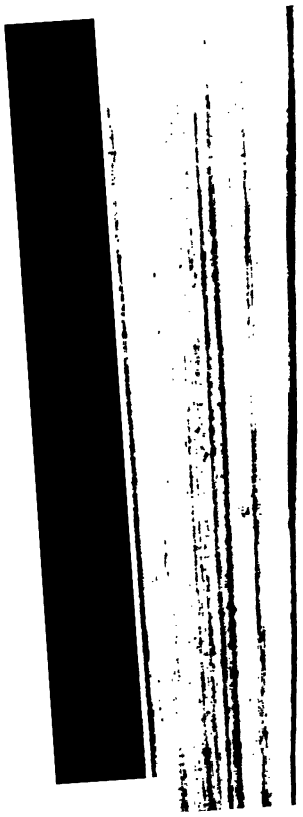
| | | |
|---|---|---|
| | | Walter Freder |
| 1893 Feb. 10 | | Rev. Edwin G. |
| 1870 Jan. 14 | * | William |
| 1870 May 13 | * | Charles Henry |
| 1872 Dec. 13 | * | Edward |
| 1894 Nov. 9 | | S. Maitland Bai |
| 1902 May 9 | * | Henry Tresawn |
| 1902 May 9 | | Maurice Edmd. |
| 1894 Mar. 9 | | A. Sarath Kuma |
| 1900 Jan. 12 | * | Umes Chandra |
| 1892 Mar. 11 | | Arthur |
| 1857 Jan. 9 | | William Bolger |
| 1867 Dec. 13 | * | Sir David |
| 1841 May 14 | * | James |
| 1871 Apr. 14 | * | J. W. L. |
| 1874 May 8 | * | Joseph |
| 1893 Apr. 14 | * | Raymond Wil |

| Date of Election. | | | |
|---|---|---|---|
| 1891 May 8 | | Thomas | Gordon, F.R.Met. Soc., 9 *Scotch Street, Whitehaven, Cumberland.* |
| 1878 Mar. 8 | | John Ellard | Gore, M.R.I.A., 3 *St. Mary's Road, Dublin, Ireland.* |
| 1883 Nov. 9 | | Eugen von | Gothard, *The Observatory, Herény, bei Steinamanger, Hungary.* |
| 1896 April 10 | | Frank L. | Grant, M.A., 58 *Kelvingrove Street, Glasgow, Scotland.* |
| 1895 Jan. 11 | | Charles Josephus | Green, M.R.C.S. L.S.A., 10 *St. Paul's Square, Preston, Lancashire.* |
| 1901 Dec. 13 | | William John | Greenstreet, M.A., *Marling School, Stroud, Gloucestershire.* |
| 1896 Nov. 13 | * | John Anderton | Greenwood, B.A. LL.M., *Funtington House, near Chichester, Sussex.* |
| 1890 Feb. 14 | | Richard A. | Gregory, *The Homestead*, 19 *Westover Road, Wandsworth Common, S.W.* |
| 1898 Jan. 14 | | Edward John | Griffin, Commr. R.N.R., 3 *Carlton Crescent, Southampton.* |
| 1878 Feb. 8 | | John E. | Griffith, *Bryn Dinas, Upper Bangor, North Wales.* |
| 1866 Nov. 9 | * | Lord | Grimthorpe, M.A. LL.D. K.C., *Batch Wood, St. Albans.* |
| 1870 Nov. 11 | | Sir Howard | Grubb, F.R.S. M.I.C.E.I., Honorary Master of Engineering, University of Dublin, 51 *Kenilworth Square, Rathgar, Dublin.* |
| 1891 Jan. 9 | * | Rev. H. Grattan | Guinness, D.D. F.R.G.S., *Harley House, Bow, E.*; and *Cliff House, Ourbar, viâ Sheffield.* |
| 1873 Nov. 14 | | Col. Gardiner F. | Guyon, Commanding 7th Regimental District, *Egerton House, Richmond, Surrey.* |
| 1879 May 9 | * | George Thorn | Gwilliam. |
| 1896 Jan. 10 | | David Edward | Hadden, *Alta, Buena Vista Co., Iowa, U.S.A.* |
| 1891 May 8 | * | George E. | Hale, D.Sc., Director of the Yerkes Observatory, *Williams Bay, Wisconsin, U.S.A.* |
| 1878 Mar. 8 | * | Rev. Frederic J. | Hall, M.A., *Northaw Place, Potter's Bar, Hertford.* |
| 1899 Feb. 10 | | John James | Hall, *Observatory Cottage, Datchet Road, Slough, Bucks.* |
| 1878 May 10 | | Maxwell | Hall, M.A., *Montego Bay, Jamaica*; and *care of Miss Hall*, 10 *Osborne Road, Clifton, Bristol.* |
| 1891 Feb. 13 | | G. P. Blackwood | Hallowes, 48 *Queen Anne's Road, York.* |
| 1895 Jan. 11 | | Frederic | Hammond, F.R.I.B.A., 38 *Mercers Road, Upper Holloway, N.* |
| 1899 Jan. 13 | | Arthur | Hands, M.R.C.S., L.R.C.P., *Inkerman House, Wednesfield Road, Wolverhampton.* |
| 1882 Jan. 13 | * | Rev. Thomas | Hands, M.A., *St. Laurence's Vicarage, Northampton.* |



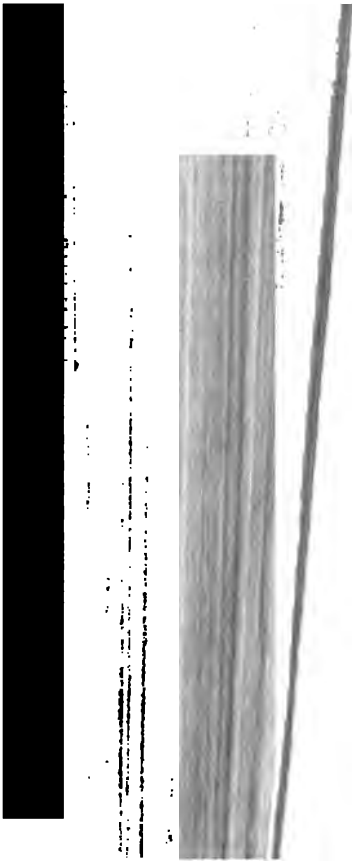
| | | |
|---|---|---|
| 1901 Jan. 11 | | Walter |
| 1878 Feb. 8 | | Henry Burdett |
| 1885 Jan. 9 | | Rev. Andrew |
| 1890 May 9 | * | Lt.-Col. George |
| 1890 Feb. 14 | | Fredk. William |
| 1864 Feb. 12 | | John B. N. |
| 1887 Apr. 6 | | Capt. M. W. C. |
| 1897 Mar. 12 | | J. Harold |
| 1867 Mar. 8 | * | Prof.Alex.Stewart |
| 1872 Feb. 9 | * | Col. John |
| 1901 Jan. 11 | * | John Chas. Wm. |
| 1901 Feb. 8 | | Adam Otto |
| 1893 Dec. 8 | * | Major Edm. H. |
| 1899 Jan. 13 | * | Arthur Robert |
| 1891 Feb. 13 | * | Shin |
| 1895 Mar. 8 | | George Denton |
| 18[illegible] | | [illegible] |

| Date of Election. | | | |
|---|---|---|---|
| 1890 Nov. 14 | | Neville | Holden, *Queen Square, Lancaster.* |
| 1884 Dec. 12 | | Henry Park | Hollis, B.A., *Royal Observatory, Greenwich*; and *2 Foyle Road, Blackheath, S.E.* |
| 1868 June 12 | | Henry William | Hollis, *Norbiton Hall, Kingston-on-Thames.* |
| 1885 Apr. 10 | | Rev. James Hardy | Honeyburne, M.A. 23 *Duke Street, Southport.* |
| 1879 Mar. 14 | * | Maures | Horner, *Mells, Frome, Somerset.* |
| 1884 Apr. 9 | | Charles | Horsley, M.Inst.C.E. F.G.S., 174 *Highbury New Park, N.* |
| 1873 Dec. 12 | * | Joseph | Hough, M.A., *Codsall Wood, near Wolverhampton.* |
| 1899 Nov. 10 | * | Sydney Samuel | Hough, M.A. F.R.S., *Royal Observatory, Cape of Good Hope.* |
| 1881 Jan. 14 | | Elijah | Howarth, *Public Museum, Weston Park, Sheffield.* |
| 1902 Jan. 10 | | Charles Sumner | Howe, Ph.D., Professor of Astronomy, *Case Observatory, Cleveland, Ohio, U.S.A.* |
| 1861 Mar. 8 | | Rev. Frederick | Howlett, M.A., 7 *Princes Buildings, Clifton, Bristol.* |
| 1898 Feb. 11 | * | Thomas Charlton | Hudson, B.A., '*Nautical Almanac' Office, Gray's Inn, W.C.*; and 37 *Lambton Road, Hornsey Rise, N.* |
| 1854 Apr. 12 | * | Sir WILLIAM | HUGGINS, Ord. of Merit, K.C.B. D.C.L. LL.D. Ph.D. D.Sc. P.R.S., FOREIGN SECRETARY, PAST PRESIDENT, 90 *Upper Tulse Hill, S.W.* |
| 1898 Feb. 11 | | David | Hunter, *St. Ronan's, Lanark, Scotland.* |
| 1885 Dec. 11 | | James | Hunter, F.R.C.S.E. F.R.P.S. F.R.S.E., *Rosetta, Liberton, Midlothian, Scotland.* |
| 1886 Dec. 10 | | Rev. Robt. Sparke | Hutchings, *The Vicarage, Alderbury, Salisbury.* |
| 1887 Jan. 14 | | Cuthbert | Hutchinson, *Rock Lodge, Roker, near Sunderland.* |
| 1902 Jan. 10 | | William Gylby | Hutchinson, *Rock Lodge, Roker, near Sunderland.* |
| 1879 Jan. 10 | | Robert T. A. | Innes, *Royal Observatory, Cape of Good Hope.* |
| 1861 Feb. 8 | * | Richard | Inwards, 20 *Bartholomew Villas, Kentish Town, N.W.* |
| 1901 Mar. 8 | | Charles John | Isaac, Head of the Upper Nautical School, *Royal Hospital School*; and 6 *Maze Hill, Greenwich, S.E.* |
| 1888 Jan. 13 | * | George James | Jacobs, *Lansdowne, Guildford, Surrey.* |
| 1890 Nov. 14 | | Harold | Jacoby, B.A. Ph.D., Adjunct Professor of Astronomy, *Astronomical Observatory, Columbia University, New York City, U.S.A.* |
| 1892 May 13 | * | Sir Otto | Jaffe, 10 *Donegall Square South, Belfast, Ireland.* |
| 1898 Mar. 11 | | Rev. Kingsbury | Jameson, M.A., *Highfield, Hendon.* |
| 1891 Jan. 9 | | Charles W. H. | Jeavons, *Horseley Place, Tipton, Staffordshire.* |
| 1878 Nov. 8 | | Benjamin George | Jenkins, 43 *Chatsworth Road, West Dulwich, S.E.* |



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|---|---|---|
| 1895 Dec. 13 | * | Rhishard Llewe |
| 1867 May 10 | * | John |
| 1900 Dec. 14 | | Sree Rajah A. V. |
| 1894 Jan. 12 | | Joshua |
| 1901 Jan. 11 | | Jas. Netherclift |
| 1894 Apr. 13 | | Wm. Redfern |
| 1868 Nov. 13 | * | Lord |
| 1893 May 12 | | Rev. Philip H. |
| 1891 Mar. 13 | | Arthur |
| 1893 June 9 | * | Arthur E. |

| Date of Election. | | | |
|---|---|---|---|
| 1859 May 13 | | Rev. Samuel | Kinns, Ph.D., 182 *Haverstock Hill, Hampstead, N.W.* |
| 1881 Jan. 14 | * | Sydney T. | Klein, F.L.S. F.E.S., *Hatherlow, Raglan Road, Reigate, Surrey.* |
| 1896 Jan. 10 | | George Handley | Knibbs, *The University, Sydney;* and *Aroca, Denison Road, Petersham, near Sydney, New South Wales, Australia.* |
| 1878 Jan. 11 | | Lt.-Col. H.S.G.S. | Knight, *The Observatory, Harestock, Littleton, near Winchester;* and *Army and Navy Club, Pall Mall, S.W.* |
| 1896 Mar. 13 | | Thomas Edward | Knightley, *Clive House, Tulse Hill, S.W.* |
| 1873 Mar. 14 | | EDWARD BALL | KNOBEL, VICE-PRESIDENT, PAST PRESIDENT, 32 *Tavistock Square, W.C.* |
| 1890 Jan. 10 | | Vernon Edwin | Knocker, *Castle Hill House, Dover.* |
| 1895 Mar. 8 | * | Lieut. Henry T.C. | Knox, F.R.G.S., late R.N., 14 *King Street, Portman Square, W.* |
| 1870 Apr. 8 | * | Carlton John | Lambert, M.A., *Royal Naval College, Greenwich, S.E.* |
| 1874 May 8 | | William James | Lancaster, F.C.S. F.G.S. F.R.M.S., *Colmore Row, Birmingham;* and *Pine Crest, Barnt Green, Worcestershire.* |
| 1899 Feb. 10 | * | Joseph | Larmor, M.A. D.Sc. F.R.S., *St. John's College, Cambridge.* |
| 1888 Nov. 9 | * | Arthur Herbert | Leahy, M.A., *Firth College, Sheffield.* |
| 1900 May 11 | | Désiré Ernest | Lebon, Agrégé de l'Université, Lauréat de l'Academie Française, Professeur de Mathématiques au Lycée Charlemagne, 4 *bis, rue des Écoles, Paris, Ve.* |
| 1876 Feb. 11 | * | Rev. Edmund | Ledger, M.A., *Protea, Reigate, Surrey.* |
| 1869 Feb. 12 | * | John | Lee, *St. Peter's Chambers, Cornhill, E.C.* |
| 1892 Jan. 8 | | Edward Herbert | Lees, *Fairhaven, Mallacoota, East Gippsland, Victoria, Australia.* |
| 1894 Jan. 12 | | Henry Alfred | Lenehan, *Government Observatory, Sydney, New South Wales, Australia.* |
| 1902 Apr. 11 | * | Capt. G. Ponsonby | Lenox-Conyngham, R.E. *Mussoorie, N.W.P., India.* |
| 1894 Jan. 12 | | Armin Otto | Leuschner, B.A. Assistant Professor of Astronomy in the University of California, *Berkeley, California, U.S.A.* |
| 1871 Mar. 10 | | Fredk. Wm. | Levander, 30 *North Villas, Camden Square, N.W.* |
| 1897 Feb. 12 | | Rev. Edw. Spry | Leverton, M.A., *The School House, Kirkham, Lancashire.* |
| 1884 Dec. 12 | | Thomas | Lewis, *Royal Observatory, Greenwich;* and *Herbert Villa, Ulundi Road, Blackheath, S.E.* |



1897 Feb. 12 Ernest

1876 June 9 * James
1902 Jan. 10 James W

1889 Feb. 8 * Arthur C.
1901 June 14 Frank

1897 Jan. 8 George Ed

1902 Mar. 14 Joseph

1862 Feb. 14 * William Th

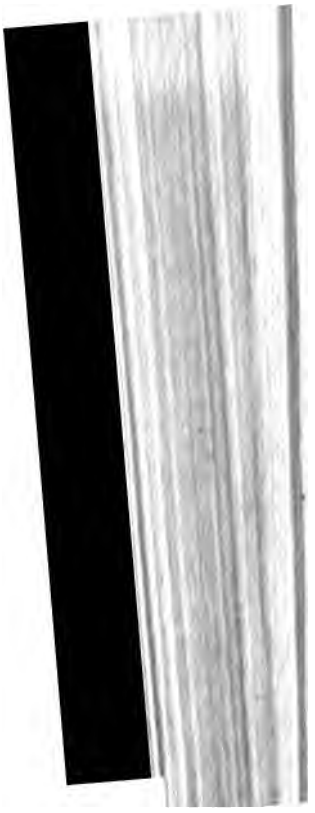
1880 June 11 Major F. De

1896 Jan. 10 Fredk. Willi

1882 Nov. 10 Jonadab
1877 Mar. 9 Frank

1886 May ..

| Date of Election. | | | |
|---|---|---|---|
| 1892 May 13 | | William Grant | MacGregor, F.R.G.S., 18 *Coleman Street, E.C.* |
| 1887 Jan. 14 | | Capt. Thomas | Mackenzie, 48 *Fenchurch Street, E.C.* |
| 1885 Apr. 10 | * | James | McKerrow, 86 *Ghuznee Street, Wellington, New Zealand.* |
| 1884 Dec. 12 | * | The Hon. Lord | McLaren, LL.D., 46 *Moray Place, Edinburgh.* |
| 1897 Jan. 8 | | MajorPercyAlexr. | MacMahon, D.Sc., F.R.S., *Artillery College, Woolwich;* and *Queen Anne's Mansions, Westminster, S.W.* |
| 1879 Mar. 14 | | Col. Ernest E. | Markwick, *Army Ordnance Department, H.M. Gun Wharf, Devonport.* |
| 1875 Jan. 8 | | Charles H. | Marten, *Conduit Lodge, Blackheath Park, S.E.* |
| 1854 Feb. 10 | * | Arthur B. | Martin, *The Laurels, Buckhurst Hill, Essex.* |
| 1901 Jan. 11 | | Capt. Joseph W. | Martyr, 1 *The Glen, South Road, Forest Hill, S.E.* |
| 1898 Jan. 14 | | J. Nevil | Maskelyne, 88 *Trinity Road, Upper Tooting, S.W.* |
| 1893 Mar. 10 | | Henry Bateman | Massey, *Spalding, Lincolnshire.* |
| 1898 June 10 | * | Peter | Matthews, *care of Zach. Cartwright, Ltd., Muscovy House, Trinity Square, Tower Hill, E.C.* |
| 1875 Feb. 12 | | Edward Walter | Maunder, *Royal Observatory, Greenwich, S.E.;* and 86 *Tyrwhitt Road, St. John's, S.E.* |
| 1888 Dec. 14 | | WILLIAM HENRY | MAW, TREASURER, 18 *Addison Road, Kensington, W.* |
| 1895 May 10 | * | John Willoughby | Meares, Electrical Engineer to Government of Bengal, *Writers' Buildings, Calcutta, India.* |
| 1877 Mar. 9 | * | Raphael | Meldola, F.R.S. F.C.S. F.I.C., Professor of Chemistry in the Finsbury Technical College, City and Guilds of London Institute, 6 *Brunswick Square, W.C.* |
| 1859 Mar. 11 | * | John James | Mellor, *The Woodlands, Whitefield, near Manchester.* |
| 1883 June 8 | * | Thomas Kilner | Mellor, *Vernon Avenue, Huddersfield.* |
| 1901 May 10 | | Charles Sidney | Mence, *Nautical Academy, 49 Watling Street, E.C.* |
| 1896 Jan. 10 | | Charles J. | Merfield, *Railway Construction, Public Works, Sydney, New South Wales, Australia.* |
| 1886 Feb. 12 | | Duncan | Milligan, 21 *Spencer Rd., New Wandsworth, S.W.* |
| 1900 Nov. 9 | | Cte. Meredyth de | Miremont, *Orleans Club, King Street, St. James's Street, S.W.;* and *Littlecot, Worthing, Sussex.* |
| 1891 Jan. 9 | * | Rev. John | Mitchell, Jun., M.A., *Bankura, Bengal, India.* |
| 1890 Dec. 12 | * | Rev. John Cairns | Mitchell, B.D., *Rutland Cottage, Parkgate Road, Chester.* |
| 1902 Apr. 11 | | S. Alfred | Mitchell, A.M., Ph.D., Lecturer in Astronomy, *Columbia University, New York City, U.S.A.* |
| 1881 Mar. 11 | | James Henry | Mitchiner, *The Acacias, Barham Road, South Croydon.* |



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|---|---|---|
| 1863 Jan. 9 | * | Richard |
| 1885 Jan. 9 | | Kavasjee D. |
| 1889 Jan. 11 | * | Frederick Wm. |
| 1875 Dec. 10 | | Commr. Chas. I |
| 1888 May 11 | | Reginald Carter |
| 1873 Feb. 14 | | Edmund Nevill |
| 1891 June 12 | * | HUGH FRANK |
| 1888 Apr. 13 | * | George James |
| 1875 Dec. 10 | * | Francis Murray |
| 1877 Apr. 13 | * | Frederic |
| 1887 May 13 | * | Gustavus Willia |
| 1902 Jan. 10 | | H. Krauss |
| 1901 June 14 | * | Charles |
| 1901 Jan. 11 | | Thomas Margit |
| 1854 June 9 | | Sir Andrew |
| 1890 Jan. 10 | * | Benjamin |
| 1855 June 8 | | |

| Date of Election. | | | |
|---|---|---|---|
| 1881 May 12 | | Samuel | Okell, *Overley, Langham Road, Bowdon, near Manchester.* |
| 1853 Jan. 14 | * | Adm. Sir Erasmus | Ommanney, K.C.B. LL.D. F.R.S. F.R.G.S., 29 *Connaught Square, Hyde Park, W.;* and *United Service Club, Pall Mall.* |
| 1902 Jan. 10 | | Capt. Michael J. | O'Sullivan, Board of Trade Surveyor, 66 *Fern Grove, Hartington Road, Sefton Park, Liverpool.* |
| 1886 Jan. 8 | * | William Irving | Page, F.R.G.S., *The White Cottage, Shanklin, Isle of Wight.* |
| 1895 June 14 | * | Rev. Jas. Dunne | Parker, LL.D. D.C.L. F.R.Met.Soc., *Bennington House, Stevenage, Herts.* |
| 1900 Jan. 12 | | Howard | Payn, F.R.G.S., 8 *Hyde Park Place, W.* |
| 1899 June 9 | | Frederick Evan | Peach, B.A., 161 *Stanstead Road, Forest Hill, S.E.* |
| 1877 Jan. 12 | * | Robert | Pearce, *Church Court Chambers, Old Jewry, E.C.* |
| 1885 Mar. 13 | | William | Feck, F.R.S.E., 6 *Hanover Street;* and *City Observatory, Calton Hill, Edinburgh.* |
| 1879 Jan. 10 | | Charles | Pendlebury, M.A., *St. Paul's School, Kensington, W.;* and 40 *Glazbury Road, West Kensington, W.* |
| 1867 Feb. 8 | | Francis Cranmer | Penrose, M.A. D.C.L. Litt.D. F.R.S., *Colebyfield, Copse Hill, Wimbledon, S.W.* |
| 1885 June 12 | | Rev. Thomas | Perkins, M.A., *Turnworth Rectory, Blandford, Dorset.* |
| 1895 Feb. 8 | * | Chas. Wm. Dyson | Perrins, *Davenham Bank, Malvern.* |
| 1889 May 10 | | James George | Petrie, 359 *Holloway Road, N.* |
| 1870 Jan. 14 | * | J. E. Hunter | Peyton, 13 *Fourth Avenue, Brighton.* |
| 1899 May 12 | | Rev. Theodore E.R. | Phillips, M.A., *Ryde House, Campbell Road, Croydon.* |
| 1891 Jan. 9 | | William M. | Pierson, 2214 *Van Ness Avenue, San Francisco, California, U.S.A.* |
| 1861 Dec. 13 | | The Rt. Hon. Lord | Pirbright, P.C. F.R.S., 42 *Grosvenor Place, S.W.* |
| 1872 June 12 | * | Major Chas. Fred. | Plant, *Ferndale, Ashgrove, Brisbane, Queensland, Australia.* |
| 1899 Dec. 8 | | Henry C. | Plummer, M.A., *University Observatory;* and 8 *Holywell, Oxford.* |
| 1879 May 9 | | William Edward | Plummer, M.A., *Liverpool Observatory, Bidston, Birkenhead.* |
| 1893 Nov. 10 | | Charles Lane | Poor, Ph.D., *Johns Hopkins University;* and 4 *East 48th Street, New York City, U.S.A.* |
| 1885 Jan. 9 | * | Rev. T. Cunningh$^{m}$ | Porter, B.A., *Eton College, Windsor.* |
| 1895 Feb. 8 | | Charles A. | Post, 16 & 18 *Exchange Place, New York City;* and *Strandhome, Bayport, Suffolk County, N.Y., U.S.A.* |

| Date of Election. | | | |
|---|---|---|---|
| 1894 Mar. 9 | | Walter A. | Post. *Newport News, Warwick County, Virginia, U.S.A.* |
| 1854 Jan. 13 | * | Eyre Burton | Powell, C.S.I. M.A., 25 *Kirkstall Road, Streatham Hill, S.W.* |
| 1901 Apr. 12 | | Rev. R. Coad | Pryor, *Bengeo Rectory, Hertford.* |
| 1896 Jan. 10 | | Hugh Griffith | Quirk, *Bay Mount, Vico Road. Dalkey, Co. Dublin, Ireland.* |
| 1893 June 9 | * | Arthur A. | Rambaut, M.A., D.Sc. F.R.S., Radcliffe Observer, *Radcliffe Observatory, Oxford.* |
| 1879 Jan. 10 | | Capt. James | Rankin, *Local Marine Board, Dock Street, E.* |
| 1902 Apr 11 | | James | Rankine, 11 *West Savile Road, Craigmillar Park, Edinburgh.* |
| 1883 Nov. 9 | | Robert | Rawson, Assoc. Inst.N.A., *Warblington Villa, Havant, Hants.* |
| 1902 Mar. 14 | | Joges Chandra | Ray, M.A., Professor of Physical Science, *Cuttack, Orissa, India.* |
| 1866 Jan. 12 | * | Lord | Rayleigh, Ord. of Merit, M.A. Sc.D. LL.D. D.C.L. F.R.S., *Terling Place, Witham, Essex.* |
| 1893 Dec. 8 | | Chas.Herbt. Edm. | Rea, A.I.A. F.S.S., 223 *Norwood Road, Herne Hill, S.E.* |
| 1888 Apr. 13 | * | Capt. Geo. Wm. | Read, F.R.G.S., *Penwerris, Cathedral Road, Cardiff, South Wales.* |
| 1892 Apr. 8 | | John Krom | Rees, A.M. E.M. Ph.D. Director of the Observatory, and Professor of Astronomy, *Columbia University, New York City, U.S.A.* |
| 1896 April 10 | | Edward Ayearst | Reeves, *Royal Geographical Society*, 1 *Savile Row, W.* |
| 1896 Feb. 14 | | Robert Fermor | Rendell, B.A., *The Glen*, 92 *Blackheath Hill, S.E.* |
| 1899 Feb. 10 | | John H. | Reynolds, 35 *Trinity Road, Birchfield. Birmingham.* |
| 1898 June 10 | | William John | Reynolds, *Varna, Fox Lane, Palmer's Green, N.* |
| 1894 Jan. 12 | | Rev.David Powell | Richards, M.A., R.N., *H.M.S.* '*Flora*,' *S.E. Coast of America.* |
| 1876 Feb. 11 | * | Rev. Walter J. B. | Richards, D.D., *St. Charles' College, Ladbroke Grove Road, Notting Hill, W.* |
| 1880 Jan. 9 | * | Arthur | Riches, *Weymouth College, Weymouth.* |
| 1870 Apr. 8 | | Edward Henry | Riches, LL.D., 78 *Southcote Road, Bournemouth.* |
| 1894 May 11 | | W. Rickmer | Rickmers, *Radolfzell am Bodensee, Germany.* |
| 1883 May 11 | | Emanuel | Ristori, Assoc.M.Inst.C.E., 2 *Halkin Street, S.W.*; and 9 *Victoria Street, Westminster, S.W.* |
| 1898 Apr. 6 | | William | Ritchie, *City Observatory, Calton Hill, Edinburgh.* |
| 1890 May 9 | | Frank | Robbins, 93 *Aldersgate Street, E.C.*; and 99 *Hurlingham Road, S.W.* |

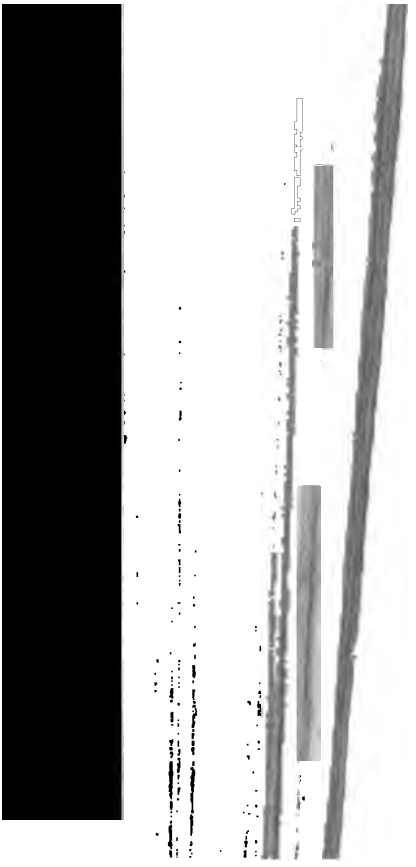
| Date of Election. | | | |
|---|---|---|---|
| 1894 Mar. 9 | | Alex. William | Roberts, D.Sc. F.R.S.E., *Lovedale, Cape Colony.* |
| 1872 Feb. 9 | | Edward | Roberts, F.S.S., *Park Lodge, Eltham, S.E.* |
| 1882 Jan. 13 | * | Isaac | Roberts, D.Sc. F.R.S., *Starfield, Crowborough, Sussex.* |
| 1890 Apr. 11 | | Edward | Robinson, 133 *Castelnau Gardens, Barnes, S.W.* |
| 1900 Feb. 9 | | William Henry | Robinson, *Offendene, Walsall, Staffordshire.* |
| 1884 Dec. 12 | | Rev.W.Jas.Boden | Roome, 13 *Cumberland Road, Acton, W.* |
| 1895 Jan. 11 | | Rev. Thomas | Roseby, M.A. LL.D., *The Manse, Marrickville, New South Wales, Australia.* |
| 1867 Dec. 13 | * | The Earl of | Rosse, K.P. B.A. LL.D. D.C.L. F.R.S., *Birr Castle, Parsonstown, Ireland;* and *Athenæum Club, Pall Mall, S.W.* |
| 1866 Apr. 13 | * | Edward John | Routh, M.A. Sc.D. LL.D. F.R.S., Fellow of the University of London, *Newnham Cottage, Queen's Road, Cambridge.* |
| 1871 Feb. 10 | | Hy.Chamberlaine | Russell, C.M.G. B.A. F.R.S., Government Astronomer, *Observatory, Sydney, N.S. Wales.* |
| 1893 Apr. 14 | | Samuel Marcus | Russell, Professor of Mathematics and Astronomy, Imperial College, Pekin, *care of Shanghai Customs, Shanghai, China.* |
| 1876 Apr. 12 | * | Sir David L. | Salomons, Bart., M.A., *Broomhill, Tunbridge Wells.* |
| 1892 Feb. 12 | * | Ralph Allen | Sampson, M.A., *Observatory House, Durham.* |
| 1902 Feb. 14 | | Charles F. | Sandberg, M.A., *Lancing College, Shoreham, Sussex.* |
| 1894 Nov. 9 | * | Samuel Arthur | Saunder, M.A., *Wellington College;* and *Fir Holt, Crowthorne, Berks.* |
| 1876 Jan. 14 | * | Harris C. L. | Saunders, *Stratford Lodge, Twickenham.* |
| 1866 May 11 | * | James Ebenezer | Saunders, F.G.S. F.L.S. F.S.A., 4 *Coleman Street, E.C.* |
| 1895 Dec. 13 | | Herbert | Savery, M.A., *The College, Marlborough, Wilts.* |
| 1869 Jan. 8 | * | Samuel | Saywell, M.A. F.L.S., *The College, Bromsgrove, Worcestershire.* |
| 1889 Jan. 11 | * | William | Schooling, 25 *Westminster Palace Gardens, S.W.* |
| 1877 Dec. 14 | * | Arthur | Schuster, Ph.D. F.R.S., Professor of Physics in Owens College (Victoria University), *Victoria Park, Manchester.* |
| 1891 Jan. 9 | | James Lidderdale | Scott, *care of Scott, Harding, & Co., P.O. Box* 120, *Shanghai, China.* |
| 1870 Apr. 8 | | George Mitchell | Seabroke, Temple Observer, *Rosemont, Rugby.* |
| 1893 Nov. 10 | * | Thos. Jefferson J. | See, Ph.D., Professor of Mathematics in the U.S. Naval Observatory, *Georgetown Heights, Washington, D.C., U.S.A.* |
| 1891 Jan. 9 | * | Arthur Laidlaw | Selby, M.A., *University College of South Wales and Monmouthshire, Cardiff, South Wales.* |

| Date of Election. | | | |
|---|---|---|---|
| 1897 Jan. 8 | | Beauchamp Prideaux | Selby, J.P., *Pawston, Cornhill-on-Northumberland.* |
| 1894 Jan. 12 | | Richard Pickering | Sellors, B.A., *Trigonometrical Survey of ... Department of Lands, Sydney, Austr...* |
| 1884 Dec. 12 | | Harold | Seward, B.A., *Patent Office, Southampton ... ings, Chancery Lane, W.C.* |
| 1861 Jan. 11 | | Philip E. | Sewell, *Gurney's Bank, Norwich.* |
| 1899 Mar. 10 | | Col. Thos. Davies | Sewell, 29 *Grosvenor Road, S.W.* |
| 1900 Dec. 14 | | Capt. Ernest H. | Shackleton, *care of Dr. Shackleton, A... House, West Hill, Sydenham, S.E.* |
| 1893 Dec. 8 | * | William | Shackleton, 14 *Bettridge Road, Parson's... S.W.* |
| 1892 June 10 | * | Martin Charles | Sharp, M.A., *Cintra, Hampstead Lane, ... gate, N.* |
| 1890 June 13 | | Thomas Steele | Sheldon, M.B.Lond., *Parkside, Macclesfi...* |
| 1878 Apr. 12 | * | Rev. Alfred J. P. | Shepherd, B.A., *The Rectory, Sulham... Reading.* |
| 1891 Jan. 9 | * | Rev. Walter | Sidgreaves, S.J., *Stonyhurst College Obse... Blackburn, Lancashire.* |
| 1857 Mar. 13 | * | James | Simms, 138 *Fleet Street, E.C.* |
| 1851 Jan. 10 | * | William | Simms, *Albert Lodge, Hope Road, S... Isle of Wight.* |
| 1890 Apr. 11 | | Andrew | Simons, F.G.S. F.R.G.S., *Sydney ... Southampton Road, Salisbury.* |
| 1894 June 8 | | David Goudie | Simpson, 199 *Camberwell Grove, Denma... S.E.* |
| 1892 Jan. 8 | | John Samuel | Slater, Professor of Civil Engineering ... Engineering Coll., *Seebpore, Calcutta,* |
| 1897 Apr. 9 | | John Sisson | Slater, M.A. LL.D., 1 *Garden Court, ... E.C.*; and *Seafield, Lytham, Lancash...* |
| 1878 Jan. 11 | * | Rev. Philip R. | Sleeman, 65 *Pembroke Road, Clifton, Bri...* |
| 1889 Dec. 13 | * | David | Smart, M.R.C.S. L.R.C.P. L.S.A., 108 ... *Road, Bermondsey, S.E.* |
| 1861 Mar. 8 | | Rev. Maurice A. | Smelt, M.A., *Heath Lodge, Cheltenham.* |
| 1884 May 9 | * | Charles Michie | Smith, B.Sc F.R.S.E., Government Astr... *Observatory, Kodaikánal, Palani Hill... India.* |
| 1894 June 8 | | Rev E. Harrison | Smith, M.A. R.N., *H.M.S.* '*Illustrious*,' ... *ranean Station.* |
| 1896 Feb. 14 | | George Albert | Smith, *St. Ann's Well, Brighton.* |
| 1896 April 10 | * | Geo.Fredk.Herbt. | Smith, M.A., *British Museum of ... History, Cromwell Road, S.W.* |
| 1876 Apr. 12 | * | John Bagnold | Smith, *Newstead Colliery, near Nottingh...* |
| 1891 Jan. 9 | | John Peter Geo. | Smith, *Sreyney Cliff, Coalport, R.S.O. ... shire.* |

| Date of Election. | | | |
|---|---|---|---|
| 1880 Jan. 9 | * | Rev. William | Smith, *The Briars, King's Road, Halstead, Essex.* |
| 1897 Feb. 12 | | William Arthur | Smith, 154 *Hagley Road, Edgbaston;* and 94 *Charlotte Street, Birmingham.* |
| 1901 Nov. 8 | | Monroe B. | Snyder, Director of the Philadelphia Observatory, *Philadelphia, Pa., U.S.A.* |
| 1898 June 10 | | William Edward | Sparkes, 8 *Claremont Terrace, Sunderland.* |
| 1895 Mar. 8 | | Rev.Danl.Higham | Sparling, B.A., *Christchurch Rectory, Biddulph Moor, near Congleton, Cheshire.* |
| 1897 Apr. 9 | | Rev. John | Spence, 13 *Elm Park Road, Chelsea, S.W.* |
| 1902 Jan. 10 | * | Charles Tallent | Spencer, A.M.Inst.C.E., *La Quinta, Lyon Road, Harrow.* |
| 1883 Jan. 12 | | Edmund Johnson | Spitta, L.R.C.P. Lond., *Ivy House,* 31 *South Side, Clapham Common, S.W.* |
| 1857 Feb. 13 | * | W. W. Spencer | Stanhope, *Cannon Hall, Barnsley, Yorkshire.* |
| 1894 Feb. 9 | | William Ford | Stanley, F.G.S. F.R.Met.Soc., *Cumberlow, South Norwood, S.E.* |
| 1880 Feb. 13 | | Captain John | Steele, *The Rectory, Flordon, near Norwich.* |
| 1899 Feb. 10 | * | Charles | Stevens, 10 *Wemyss Road, Blackheath, S.E.* |
| 1878 Mar. 8 | | Frederick Haller | Stevens, B.A., *Clifton College, Bristol.* |
| 1874 Dec. 11 | | Capt. Geo. Richd. | Stevens, *Hong Kong, China.* |
| 1865 Jan. 13 | * | Robert Norton | Stevens, *Woodham, near Woking Station, Surrey.* |
| 1884 Mar. 14 | | John Torrens | Stevenson, *Nelson Street, Auckland, New Zealand.* |
| 1888 Mar. 9 | * | Rev. Walter Edw. | Stewart, M.A., *Elvott House, Hurworth-on-Tees, Darlington.* |
| 1894 May 11 | | William Stewart | Stewart, *Levern, Barrhead, Scotland.* |
| 1894 June 8 | * | Sir John Benjamin | Stone, M.P. J.P. F.L.S. F.G.S. F.R.G.S., *The Grange, Erdington, near Birmingham.* |
| 1860 Feb. 10 | * | G. Johnstone | Stoney, M.A. D.Sc. F.R.S., 30 *Ledbury Road, Bayswater, W.* |
| 1861 Jan. 11 | | John Matthew | Stothard, M.D., *Laurel Lodge, Monkstown, Co. Dublin, Ireland.* |
| 1869 Mar. 12 | | Lt.-Col. George | Strahan, R.E., *Dehra Dûn, N.W.P., India.* |
| 1892 Nov. 11 | | Edward | Stroud, *Coopers' Company's School, Tredegar Square, Bow;* and 74 *Marquess Road, Canonbury, N.* |
| 1901 May 10 | | Rev. Edw. John | Stutter, O.S B., *Acton Burnell, near Shrewsbury.* |
| 1898 Jan. 14 | * | Ambrose | Swasey, *Cleveland, Ohio, U.S.A.* |
| 1879 Apr. 9 | | Lewis | Swift, *Marathon, Cortland Co., N.Y., U.S.A.* |
| 1890 Jan. 10 | * | Hy. Wm. Lloyd | Tanner, M.A. F.R.S., Professor of Mathematics in the University College of South Wales and Monmouthshire, 27 *Cwrt-y-Fil Road, Penarth, South Wales.* |

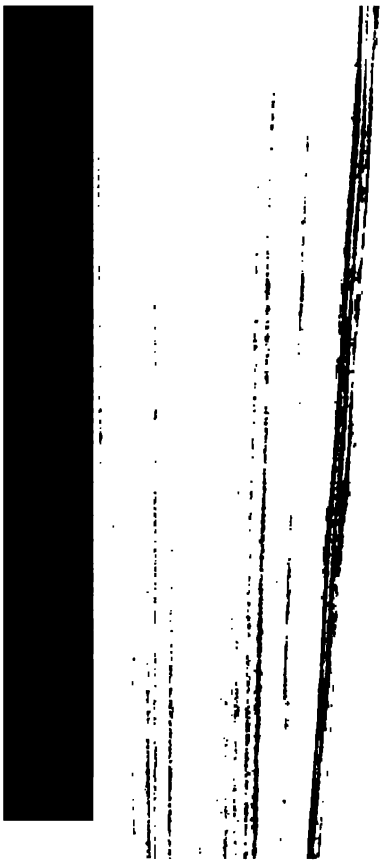
| Date of Election. | | | |
|---|---|---|---|
| 1889 Feb. 8 | | Kenneth James | Tarrant, *Craven* and 63 *Threa* |
| 1892 Nov. 11 | * | John | Tatlock, Jun., M *City, U.S.A.* |
| 1888 Dec. 14 | | Albert | Taylor, *Gorphwy South Wales.* |
| 1898 Mar 11 | | Alfred | Taylor, *c/o T. Co York;* and *I* |
| 1894 Dec. 14 | | Basil R. H. | Taylor, Assis. Ha |
| 1896 Feb. 14 | | Charles Albert | Taylor, 56 *Rams* |
| 1885 May 8 | * | C. H. Brewitt | Taylor, *care of I.* |
| 1899 Dec. 8 | | Clement Jennings | Taylor, *Derby* *Cape Town, S* |
| 1875 May 14 | * | Henry Martyn | Taylor, M.A. F.R |
| 1886 Dec. 10 | | Washington | Teasdale, F.R.M. |
| 1873 Jan. 10 | | John | Tebbutt, *Observa* |
| 1896 Apr. 10 | | Theodore Martin | Teed, C.E. F.R. *Denmark Hi* |
| 1855 June 8 | * | Lt.-Gen. Jas. F. | Tennant, C.I.E. 11 *Clifton G* |
| 1874 Nov. 13 | * | Dr. François | Terby, 96 *rue de* |
| 1881 Mar. 11 | * | Rev. Thomas R. | Terry, M.A., *T Newbury, Be* |
| 1890 Jan. 10 | | Wm. Grasett | Thackeray, *Roya* 15 *Shooter's* |
| 1888 May 11 | | Sir Henry | Thompson, Ba *Wimpole St* |
| 1880 June 11 | * | Capt. Peter | Thompson, 26 *H* |
| 1875 May 14 | | Silvanus Phillips | Thompson, B.A. fessor of Ph London Tec *land, Chislet* |
| 1885 Jan. 9 | * | Capt. Benjamin | Thomson, Lieut *Bickington,* |
| 1875 Feb. 12 | | Wm. Henry | Thornthwaite, *E.C.;* and *Walton-on-T* |
| 1892 Jan. 8 | | Arthur | Thornton, M.A. *lington, Yor* |
| 1902 Apr. 11 | | Thomas | Thorp, *Moss Ba* |
| 1886 Feb. 12 | * | Christopher | Thwaites, M.I.C |
| 1899 Feb. 10 | | William Harold | Tingey, B.A. *Rochester, K* |
| 1864 Apr. 8 | | Sir Charles | Todd, K.C.M.G. nomer, *Obser* |

| Date of Election. | | | |
|---|---|---|---|
| 1854 Feb. 10 | * | Captain Henry | Toynbee, 12 *Upper Westbourne Terrace, W.* |
| 1886 Jan. 8 | * | Julien | Tripplin, 31 *Holborn Viaduct, E.C.*; and 23 *Heathfield Gardens, Chiswick, W.* |
| 1896 Dec. 11 | | John Burt | Trivett, Assistant Government Statistician and Actuary to the Public Service Board, *Government Statistician's Office, Sydney, N.S.W., Australia.* |
| 1863 May 8 | * | Lieut.-Col. G. L. | Tupman, R.M.A., *Hillfoot Observatory, College Road, Harrow.* |
| 1885 Jan. 9 | * | Herbert Hall | Turner, D.Sc. F.R.S., Savilian Professor of Astronomy, Oxford, *University Observatory, Oxford.* |
| 1902 Jan. 10 | | Rev. C. Lakeman | Tweedale, M.A., *The Vicarage, Weston, near Otley, Yorks.* |
| 1864 Nov. 11 | | Edward | Tyer, *Ashwin Street, Dalston, E.* |
| 1883 June 8 | | Wm. John Vernon | Vandenbergh, F.R.Met.Soc., *care of G. B. Smith, 6 Malvern Road, Hornsey, N.* |
| 1867 Apr. 12 | * | Frederick Henry | Varley, 82 *Newington Green Road, Islington, N.* |
| 1898 Jan. 14 | | John | Vaughan, Lieut. R.N.R., Commr., *China Navigation Company, Shanghai, China.* |
| 1856 Jan. 11 | | Rev. George | Venables, *Burgh Castle Rectory, near Great Yarmouth.* |
| 1901 Feb. 8 | | Rev. George | Vickars-Gaskell, *Grange-over-Sands, N. Lancashire.* |
| 1881 Feb. 11 | | James George | Vine, 35 *Glen Eagle Road, Streatham, S.W.* |
| 1879 Nov. 14 | | Henry T. | Vivian, *Eversley, Winchfield, Hants.* |
| 1895 Jan. 11 | | Rev. Peter Hately | Waddell, *The Manse, Whitekirk, Prestonkirk, East Lothian, Scotland.* |
| 1901 May 10 | * | Ernest George | Wainwright, B.A., *St. John's College, Battersea, S.W.* |
| 1891 Jan. 9 | * | Arthur John | Walker, M.A., *Mount St. John, Thirsk, Yorkshire.* |
| 1883 Jan. 12 | * | William Henry | Walmsley, B.Sc., *'Nautical Almanac' Office, 3 Verulam Buildings, Gray's Inn, W.C.* |
| 1902 Feb. 14 | | Albert | Walter, *Royal Alfred Observatory, Mauritius.* |
| 1888 May 11 | | John | Walther, M.D. C.M. F.R.Met. Soc., 109 *Marina, St. Leonards-on-Sea.* |
| 1863 Feb. 13 | | Col. M. Foster | Ward, *Bannerdown House, Batheaston, Somerset*; and *Partenkirchen, Bavaria.* |
| 1888 Jan. 13 | * | Francis James | Wardale, *The Limes, Shrewton, S.O., Wiltshire.* |
| 1876 Jan. 14 | * | Major-Gen. W. H. | Wardell, R.A., *Sparkford Lodge, Winchester.* |
| 1899 Jan. 13 | * | Worcester R. | Warner, *Cleveland, Ohio, U.S.A.* |
| 1887 June 10 | * | Hy. Addenbrook | Wassell, *Addenbrook Villa, Love Lane, Stourbridge.* |



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|---|---|---|
| 1878 Jan. 11 | | R |
| 1888 Feb. 10 | | R |
| 1879 Nov. 14 | * | R |
| 1875 June 11 | | Fr |
| 1899 Feb. 10 | | Th |
| 1897 Feb. 12 | | Edv |
| 1901 Jan. 11 | | Ric |
| 1902 Apr. 11 | | Will |
| 1877 Jan. 12 | * | Rear |
| 1902 Feb. 14 | | Edwa |
| 1869 Jan. 8 | * | Edwar |
| 1893 Mar. 10 | * | Edwar |
| 1898 Dec. 9 | | Charles |
| 1898 Feb. 11 | * | EDMUN |
| 1898 Feb. 11 | | Walter |

| Date of Election. | | |
|---|---|---|
| 1895 May 10 | William | Willett, Junr., *The Cedars, Chislehurst Common, Kent;* and 2 *Sloane Gardens, S.W.* |
| 1884 May 9 | * Arthur Stanley | Williams, *Bella Vista*, 20 *Hove Park Villas, Hove, Sussex.* |
| 1865 Dec. 8 | * Harry Samuel | Williams, M.A., 6 *Heathfield, Swansea, South Wales.* |
| 1875 Dec. 10 | * William E. | Wilson, F.R.S., *Daramona, Streete, Rathowen, Ireland.* |
| 1860 Mar. 9 | Rev. Thomas | Wiltshire, M.A. D.Sc. F.G.S. F.L.S., Emeritus Professor of Geology and Mineralogy, King's College, London; 25 *Granville Park, Lewisham, S.E.* |
| 1898 May 13 | Rev. Wm. Edward | Winks, 58 *Richmond Road, Cardiff, South Wales.* |
| 1894 Jan. 12 | Max | Wolf, Ph.D., Professor der Astronomie an der Universität, *Astrophysikalisches Observatorium, Heidelberg, Germany.* |
| 1877 Feb. 9 | * Arthur Mason | Worthington, M.A. F.R.S., *R.N.E. College, Devonport;* and *Mohuns, Tavistock, Devon.* |
| 1879 Jan. 10 | Arthur W. | Wright, Ph.D., Professor of Physics at Yale University, *New Haven, Connecticut, U.S.A.* |
| 1867 Apr. 12 | * Stephen M. | Yeates, 2 *Grafton Street, Dublin.* |
| 1862 Dec. 12 | Sir Allen | Young, C.B., 18 *Grafton Street, Bond Street, W.* |
| 1896 May 8 | Alfred Ernest | Young, Assoc.M.Inst.C.E., *Trigonometrical Survey of Perak, Taiping, Perak, Straits Settlements.* |
| 1877 Jan. 12 | * Jesse | Young, F.R.G.S., *Wisbech, Cambridgeshire.* |
| 1898 Jan. 14 | Thomas Emley | Young, B.A., Pres. Inst. Actuaries, 108 *Evering Road, Stoke Newington, N.* |
| 1875 June 11 | Prof. C. Venceslas | Zenger, *Palais Lobkowitz 7/III. Prague Bohemia.* |

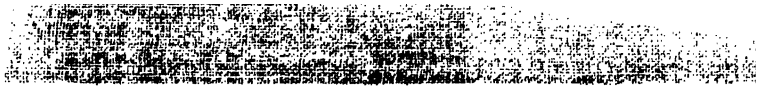


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| 1898 Dec. 9 | O. |
| 1882 Nov. 10 | H. G. va |
| 1898 Dec. 9 | Edward |
| 1890 Dec. 12 | Lewis |
| 1884 Nov. 14 | Theodor |
| 1898 Dec. 9 | Sherburne |
| 1901 Nov. 8 | W. W. |
| 1889 Nov. 8 | Seth C. |
| 1898 Dec. 9 | Colonel Gilb |
| 1889 Nov. 8 | Nils Christia |
| 1892 Nov. 11 | |

| Election. | | |
|---|---|---|
| May 12 | Johann Gottfried | Galle, Ph.D., Professor, *Kiel-Strasse 17, Potsdam, Germany.* |
| Nov. 10 | George E. | Hale, D.Sc. F.R.A.S., Director of the Yerkes Observatory, *Williams Bay, Wisconsin, U.S.A.* |
| Jan. 10 | Asaph | Hall, *Goshen, Connecticut, U.S.A.* |
| Nov. 10 | Friedrich Robert | Helmert, Ph.D., ordentliche Professor an der Universität, Berlin; Director des Königl. preussischen Geodätischen Instituts und des Centralbureaus der Internationalen Erdmessung, *Potsdam, Germany.* |
| Nov. 8 | Paul P. | Henry, Astronome à l'Observatoire, *Paris.* |
| Nov. 8 | Prosper M. | Henry, Astronome à l'Observatoire, *Paris.* |
| Nov. 8 | George William | Hill, Ph.D., *West Nyack, N.Y., U.S.A.* |
| Nov. 14 | Edward Singleton | Holden, M.A. Sc.D. LL.D., *U.S. Military Academy, West Point, N.Y., U.S.A.* |
| Nov. 8 | Jules | Janssen, Membre de l'Institut et du Bureau des Longitudes, Directeur de l'Observatoire d'Astronomie Physique, *Meudon, Seine-et-Oise, France.* |
| Nov. 11 | Jacobus Cornelius | Kapteyn, Ph.D. Professor of Astronomy at the University, *Groningen, Holland.* |
| Nov. 10 | Friedrich | Küstner, Ph.D., Professor der Astronomie an der Universität und Director der Königlichen Sternwarte, *Bonn, Germany.* |
| Nov. 9 | Samuel Pierpont | Langley, LL.D., Secretary of the Smithsonian Institution, *Washington, D.C., U.S.A.* |
| Nov. 12 | Maurice | Loewy, Membre de l'Institut et du Bureau des Longitudes, Directeur de l'Observatoire de Paris, 119 *bis, rue Notre Dame des Champs, Paris.* |
| Nov. 9 | Albert A. | Michelson, Ph.D., Professor of Physics in the University, *Chicago, U.S.A.* |
| Nov. 8 | Simon | Newcomb, Professor, 1620 *P Street, Washington, D.C., U.S.A.* |
| Nov. 14 | Magnus | Nyrén, Ph.D., Astronom der Sternwarte, *Pulkowa, Russia.* |
| Nov. 9 | J. A. C. | Oudemans, Ph.D., Professor, *Utrecht, Holland.* |







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